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Impact assessment support study for the review of the Community guidelines on State aid for railway undertakings

Final Report

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Abstract

In the wake of stagnant modal share of the European rail freight sector, this support study provides market information for the revision of the Guidelines on State aid for railway undertakings. It addresses four areas of interest: status of rail infrastructure; accessibility and costs pertaining to rolling stock; profitability and demand elasticity of rail freight services; and effectiveness of State support measures. A novel dataset of costs and revenues of rail freight across Europe, compiled using both publicly available data and input from extensive stakeholder consultation was built for that purpose. The findings are as follows. The inadequacy of intermodal terminals, congested rail networks, and costliness of private sidings all restrict the capacity of European rail infrastructure. Access to rolling stock is characterised by high costs and a lack of technical standardisation across Member States. We find that rail freight sectors in many countries are loss-making, with some segments being profitable. Efficient transshipment and transport of high freight volumes over long distances improves profitability of intermodal operations. The study shows that price sensitivity of rail freight services differs depending on the level of competition faced by road transport. The study also highlights to what extent higher thresholds for proportionate State aid and improved flexibility of schemes could be considered.

Résumé

Face à la stagnation de la répartition des parts de marché du secteur européen du fret ferroviaire, cette étude de soutien fournit des informations sur le marché et ce en vue de la révision des lignes directrices sur les aides d'État aux entreprises ferroviaires. Elle aborde quatre domaines d'intérêt: l'état de l'infrastructure ferroviaire ; l'accessibilité et les coûts relatifs au matériel roulant ; la rentabilité et l'élasticité de la demande des services de fret ferroviaire ; et l'efficacité des mesures de soutien de l'État. Un nouvel ensemble de données sur les coûts et les revenus du fret ferroviaire en Europe, compilé à l'aide de données publiques et de contributions provenant d'une vaste consultation des parties prenantes, a été construit à cette fin. Les conclusions sont les suivantes. L'inadéquation des terminaux intermodaux, l'encombrement des réseaux ferroviaires et le coût des embranchements privés limitent tous la capacité de l'infrastructure ferroviaire européenne. L'accès au matériel roulant se caractérise par des coûts élevés et un manque de normalisation technique dans les États membres. Nous constatons que les secteurs du fret ferroviaire de nombreux pays sont déficitaires, malgré quelques segments étant rentables. L'efficacité du transbordement et du transport de gros volumes de fret sur de longues distances améliore la rentabilité des opérations intermodales. L'étude montre que la sensibilité au prix des services de fret ferroviaire diffère selon le niveau de concurrence auquel est confronté le transport routier. L'étude souligne également dans quelle mesure des seuils plus élevés pour les aides d'État proportionnées et une meilleure flexibilité des régimes pourraient être envisagés.

Zusammenfassung

Angesichts des stagnierenden Anteils des europäischen Schienengüterverkehrs an allen Verkehrsträgern liefert diese Studie Marktinformationen für die Überarbeitung der Leitlinien für staatliche Beihilfen an Eisenbahnunternehmen. Sie befasst sich mit vier Bereichen: Zustand der Schieneninfrastruktur, Zugänglichkeit und Kosten des rollenden Materials, Rentabilität und Nachfrageelastizität des Schienengüterverkehrs und Wirksamkeit staatlicher Fördermaßnahmen. Zu diesem Zweck wurde ein neuartiger Datensatz zu den Kosten und Erträgen des Schienengüterverkehrs in ganz Europa erstellt, der sowohl aus öffentlich verfügbaren Daten als auch aus Erkenntnissen aus einer umfassenden Konsultation der Interessengruppen zusammengestellt wurde. Die Ergebnisse lauten wie folgt: Unzureichende intermodale Terminals, überlastete Schienennetze und kostspielige private Gleisanschlüsse schränken die Kapazität der europäischen Eisenbahninfrastruktur ein. Der Zugang zum rollenden Material ist durch hohe Kosten und einen Mangel an mitgliedsstaatenübergreifender technischer Standardisierung gekennzeichnet. Im Ergebnis zeigt sich, dass Schienengüterverkehr in vielen Ländern defizitär ist, wobei einige Segmente profitabel sind. Ein effizienter Güterumschlag und die Beförderung großer Frachtmengen über große Entfernungen verbessern die Rentabilität des intermodalen

Verkehrs. Die Studie zeigt, dass die Preisempfindlichkeit des Schienengüterverkehrs je nach Grad des Wettbewerbs mit dem Straßengüterverkehr unterschiedlich ist. Die Studie zeigt auch, dass höhere Schwellenwerte für verhältnismäßige staatliche Beihilfen und eine größere Flexibilität der Regelungen in Betracht gezogen werden könnte.

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List of abbreviations

AEFP	Asociación de Empresas Ferroviarias
ARE	Federal Office for Spatial Development
ALLRAIL	Alliance of Passenger Rail New Entrants in Europe
ATO	Automatic train operations
ATC	Automatic train control
BCP	Border crossing point
BMVI	German Federal Ministry of Transport and Digital Infrastructure
BT	Block trains
CbM	Condition-based maintenance
CCS	Control-Command and Signalling
CEF	European funds under connecting Europe facility
CH	Switzerland
CT	Combined transport
DAC	Digital Automated Coupling
DG COMP	Directorate General for Competition of the European Commission
EAC	Equivalent annual cost
EC	European Commission
ECVVR	European Centralised Virtual Vehicle Register
ERA	European Union Agency for Railway
ERFA	Europan Rail Freit Association
ERTMS	European Rail Traffic Management System
EU	European Union
EU JU	Europe's Rail Joint Undertaking
EVN	European Vehicle Number
FCH	Fuel Cell and Hydrogen
FRMCS	Future Railway Mobile Communication System
FVG	Friuli Venezia Giulia
GHG	Greenhouse gas
GSM-R	Global System for Mobile communications for Railways
HGV	Heavy goods vehicle
HHI	Herfindahl-Hirschman index
HS	High speed
IM	Infrastructure manager
IRG	Independent regulators' group
IWW	Inland waterways
LI	Load Index
LU	Loading unit
MR	Market regulator

MS	Member State
MU	Multiple unit
NDTAC	Noise-differentiated track access charges
NST	Nomenclature uniforme des marchandises pour les statistiques de transport
NVR	National Vehicle Registers
PAMI	Modernisation and innovation aid plan for the river fleet
PARM	Aid plan for modal shift towards inland waterway
PdM	Predictive Maintenance
RG	Railway Guidelines
RoMo	Rolling motorway
RU	Railway undertaking
SA	State aid
SNCF	Société Nationale des Chemins de Fer
SSS	Short sea shipping
SW	Single-wagon
TAC	Track access charges
TCO	Total cost of ownership
TIM	Train Integrity Monitoring
Tkm	Tonne-kilometres
TS	Technical specifications
TSI	Technical specifications for interoperability
TT	Transshipment technology
UIC	International Union of Railways
UIP	International Union of Wagon Keepers
UK	United Kingdom
US	Urban systems
VC	Virtual Coupling
VDV	Association of German Transport Company
VHS	Very high speed
WTW	Well-to-Wheel

Executive summary

Once at the frontier of freight transport logistics, rail lost its dominant position to road transport. Although rail transport remains competitive in some segments, its modal share of freight transport in Europe has steadily declined through the second half of the 20th century. There are various reasons for this decline, including the structural economic shift away from heavy industries which induced demand for more flexible road transport solutions, large-scale investments into road infrastructure and innovations in road logistics. The liberalisation of the national rail freight sectors in Europe in the last two decades has not been sufficient to reverse this trend.

In the context of the European Green Deal, the European Union (EU) aims at doubling rail freight traffic by 2050. The revision of the current Community Guidelines on State aid for railway undertakings (Railway Guidelines, RG) aims at supporting the achievement of this ambitious goal. The Directorate General for Competition of the European Commission (DG COMP) has commissioned the consortium consisting of E.CA Economics, LEAR, Sheppard Mullin and UEA (the Consortium), supported by the Institute for Transport Studies at the University of Leeds, with an external study to support the revision of the RG. This study provides detailed market information, based on desk research and data collection, including a targeted stakeholder consultation, to inform the RG revision process. The study addresses the following topics: i) overview of State aid and other State support measures for rail freight transport; ii) rail infrastructure including private sidings; iii) modernisation and access to rolling stock; iv) cost, revenue and profitability of rail freight services and intermodal transport as well as price elasticity of demand for rail freight services. Finally, the study provides conclusions on the design of State aid for rail freight.

The rail freight sector differs significantly across European countries. In 2019, the last pre-pandemic year, the rail modal share (based on transport volume of road, rail, inland waterway transport and short-sea shipping in tonnes) ranged from an average of 4.1% in Southern European countries to 14.5% in Eastern Europe. The top five types of freight transported by rail included containerised goods, metal ores, coke, coal, and basic metals. Together, these accounted for around 67% of total rail freight volume in the EU. Aside from containerised goods, these types of freight are usually transported by block trains. Intermodal transport, which uses intermodal loading units such as containers and swap bodies, is a growing segment within the rail freight sector. Its share in total rail transport significantly varied across countries, ranging from 1.4% in Latvia to 80% in Greece. Single-wagon operations are in decline, even no longer being offered in several Member States. Across Europe, the average distance travelled by a tonne of freight within a country ranged from 43 km to 415 km, with an average of 241 km. The rail freight market structure also varied a lot: The share of the incumbent in 2019 spanned from 0% to more than 90%.

Overview of State aid in the rail freight sector

To better understand the nature of state support measures for intermodal services and rail freight, a database of 156 relevant European Commission (EC) State aid decisions was collated from the European Commission's case search database and supplemented with further desk research to ascertain state support measures in Switzerland and support that is not State aid.

We identified 104 state support measures supporting rail freight and the modal shift of freight traffic away from road to more environmentally friendly modes of transport (rail, inland waterway and maritime). The schemes became significantly more popular over time: We observed 34 schemes in operation in 2012 and 64 schemes in operation in 2021, with a total budget of €338.06 million in 2012 and €2.29 billion in 2021.

There was also significant diversity, both in scheme type and the modes of transport supported: Across the sample we identified 88 measures supporting the rail freight transport industry, 58 measures supporting intermodal infrastructure, 15 measures supporting the maritime industry, and 31 measures related to the inland waterway sector. We also identified significant diversity within scheme types, supporting a wide variety of different projects and beneficiaries. For example, within the rail freight transport industry, although we predominately observe schemes open to rail freight operators and terminal owners, we also observed a small minority of schemes which were open to other beneficiaries, such as research facilities and rolling stock producers.

The aggregate level of operating State aid per tkm approved by the European Commission in 2019 – being the last pre-pandemic year – was insignificant for most Member States. Notable exceptions are Austria (0.71 ct/km) and Italy (0.48 ct/km), the former effectively keeping single-wagon operations and accompanied intermodal transport in the market, and the latter having difficulties in fostering the rail freight modal share, despite a relatively high level of operating State aid. In 2019, the Czech Republic, Lithuania and Poland did not report any State aid for operating rail freight in that year. This does not preclude that State aid was granted at intensities below the levels required for notification.

To assess the extent to which these schemes have been effective in supporting a modal shift from road to rail and other more environmentally friendly modes of transport, the database is matched with financial information on planned and/or actual spending and modal share data. This data shows that the share of freight carried by modes of transport prioritised for state support has declined, but the actual level of the total rail transport volume (in tonnes) has increased between 2012 and 2019.

The changes in modal shares vary substantially across Member States. With combined rail, inland waterway (IWW) and short sea shipping (SSS) shares exceeding 45% of freight tonnes, Latvia and Lithuania experienced a combined non-road share decline in tonnes that exceeded 10 percentage points from 2012-2019. Modest increases in non-road modal shares between 2012 and 2019 were found for the combination of rail, IWW and SSS of between 1-7 percentage points of tonnes for Bulgaria, Greece, Finland, Portugal, Ireland, France, Denmark and Switzerland. The number of State support schemes for non-road transport and the amount of funding given varies across Europe: Some countries with a high rail/IWW/SSS modal share (or relatively high changes in share) have no schemes, while other countries with low rail/IWW/SSS modal share (or relatively low changes in share) have multiple schemes. The complex factors affecting transport and the paucity of available data make it difficult to identify exactly which ones affect modal share changes. The correlations between state support and rail/IWW/SSS modal share, and the correlation between the changes in these two variables, are weakly negative. However, the lack of a firm correlation at an aggregate level does not mean that specific schemes have no effect: More focused geographic and temporal interview evidence can indicate otherwise, as with the reversal of a decline in rail share apparently arising from building a new terminal in Luxembourg.

Rail infrastructure

European railway infrastructure is a complex system, comprising national railway networks with different types of service facilities and intermodal terminals, as well as private sidings. Each part is complementary to the other. It should thus be understood that a bottleneck at one level of the infrastructure system can create disruptions at other levels, and could hinder the goal of the modal shift. Therefore, to ensure that more intense rail traffic can be served without causing delay, the overall rail infrastructure needs not only to be able to manage the current workload, but also to meet increased demand.

The analysis of publicly available data on the number of facilities for rail transport indicates that in some countries the existing facilities might be insufficient to satisfy even the current level of demand. The density of service facilities in particular has been analysed: More dispersed facilities can increase the costs associated with rail transport, both because of the greater time needed to reach the facilities, and because of higher risks of congestion. Still, an analysis of density can only tell part of the story, as it does not account for the facilities' capacity. On this point, the market regulators who have responded to the stakeholder surveys have indicated that in general the facilities ensure good availability of the services provided.

From the interviews carried out by the Consortium it has emerged that relevant stakeholders consider the number of essential facilities in Europe to be insufficient, both in terms of numbers and capacity. The market share for the provision of services is skewed in favour of vertically integrated incumbents, which may provide them with the ability to discriminate against other market participants. While access to the services provided by these facilities should be ensured in a non-discriminatory way according to Directive 2012/34, this obligation may be difficult to monitor for national authorities due to the many factors that affect the actual ability of railway undertakings (RU) to access them (such as maximum capacity of the facility, efficiency of services offered, and actual time required for operations).

The Consortium has also examined the adequacy of intermodal terminals. Both the analysis of public data and the existing literature point toward a lack of intermodal terminal across Europe: In many countries intermodal terminals seem to be overloaded, i.e. they have to manage more freight than is optimal, which could be leading to delays and train cancellations. While some managers of intermodal terminals interviewed by the Consortium have highlighted that the terminals operate profitably, and that if there was excess demand to be met, more terminals would be built, it should be noted that there is a certain degree of heterogeneity in the number (and type) of intermodal terminals across regions. Indeed, it is likely that while the intermodal terminals that have been analysed for the case studies are profitable and able and willing to increase their capacity, other intermodal terminals located elsewhere might not be; moreover, there could be a lack of specific types of intermodal terminals (such as road/inland-waterways), as highlighted by some participant of the stakeholder survey.

Finally, intermodal terminals managers, as well as stakeholders interviewed for the study, such as the European Rail Freight Association (ERFA), Alliance of Passenger Rail New Entrants in Europe (ALLRAIL), and the Community of European Railway and Infrastructure Companies (CER), have highlighted that the existing railway network in Europe is congested and not suited to operate more and longer trains. This claim has also been backed up by a shipper interviewed by the Consortium.

The evidence collected suggests that both issues affect the capacity of European railway infrastructure: There might be a lack of intermodal terminals in certain countries, but this does not exclude the possibility that the existing railway network is congested. The fact that terminals might be lacking in specific areas is likely due to the low returns that the investment could ensure. Loss-making terminals might need support to remain in business, although they increase the pool of choice for shippers and the connection to the national railway network, thus reducing the negative externalities caused by road haulage, possibly allowing different parts of the networks to be used more, and redirecting traffic from congested areas. If one wanted to promote intermodal transport, the trade-off between a denser intermodal terminal network and the cost of sustaining them should be considered.

The existing railway network is not owned and operated exclusively by infrastructure managers. Private sidings are privately owned rail tracks that connect loading points (e.g., industrial plants or warehouses) to the main railway network, allowing companies to avoid road transport for the first and/or last mile. By moving goods directly between the public railway infrastructure and their own premises, companies can reduce the exposure to logistic disruptions such as driver shortages or roads congestion. Most of the rail freight transport in Europe spends at least part of its journey on private sidings. This includes almost 85% of transport volumes in Germany, around 60% in Austria, and 70% in Slovakia. If one wanted to promote the modal shift to rail, sidings could thus be pivotal. However, there seems to be a general decline in the number of private sidings around Europe; for instance, in Germany, the number of sidings decreased from about 13,000 in 1993 to 1,300 in 2013, while in Austria it declined from 840 in 2010 to 521 in 2020.

Despite the benefits that private sidings can provide, road transport solutions are usually cheaper in the short term (and possibly in the long-term, unless a certain threshold of freight moved can be reached) and are therefore sometimes still preferred by private companies. Generally speaking, sidings are an investment with a long expected technical useful life (around 30 years, according to a response to the stakeholders' survey). Still, the economic useful life can be curtailed because of the risk that in the future the siding might not be served anymore.

When considering whether to support the development of new private sidings, the factors that influence the business case for them are relevant. Indeed, while direct subsidy schemes (such as the ones already existing, *inter alia,* in Austria and Germany), aimed at directly reducing construction costs, are one possible solution, one should consider how the different factors (e.g. the freight moved and the length of the siding) affect the business case of building a siding. The development of new sidings could potentially be promoted also through other policies, that leverage the interplay between the siding and the railway infrastructure: For instance, increasing the density of the railway network could reduce the length of a siding, and thus construction cost and the funding gap. Both direct subsidies and other policy options could potentially be combined if one aimed at enhancing the development of new sidings.

Rolling Stock

From the *fitness check* of the Railway Guidelines carried out between 2019 and 2020 by the European Commission there emerged a concern that rolling stock in the EU may be too old.

The literature shows that in 2019 more than 50% of the freight wagon fleet in Europe was more than 30 years old, with the same source estimating its average useful life as between 35 and 50 years. Analysis of the National Vehicle Registers shows that the situation does not seem to have improved in the last three years: Passenger rolling stock is, on average, even older than freight rolling stock, whereas tractive rolling stock is on average younger. Shunting and miscellaneous locomotives (e.g., steam locomotives), which are on average almost 40 years old, represent an exception. A factor which could thwart the EU Sustainable and Smart Mobility Strategy goal to double rail freight transport by 2050 is that at the current rate of renewal the sector is heading towards a net reduction in the size of the fleet. This is due to the fact that a high proportion of the rolling stock fleet is approaching the end of its useful life, and it seems unlikely that there currently exists enough spare capacity to satisfy the desired increase in volumes. While this can be partially mitigated by retrofitting old rolling stock, that alone will likely not be sufficient to reverse the reduction of the fleets.

The Consortium investigated the causes of this situation, and in particular what constrains railway undertakings' ability to invest in the retrofitting or replacement of rolling stock. We found that the constraints are mainly financial and that small operators in particular may not have access to credit on competitive terms. This could also lead smaller undertaking to use rolling stock which is economically obsolete, i.e. rolling stock with higher operating costs, which would be more profitable to replace or retrofit. These financial constraints may also generate a competitive advantage for State-owned railway undertakings; the latter may be able to access credit on better terms due to implicit or explicit State guarantees. While there has been a steady increase in the level of private financing since 2011, a certain heterogeneity can be observed across market segments, with more liberalised segments showing a higher concentration of private financing. Thus, given the state of the rolling stock fleet in Europe, and its suboptimal rate of renewal, public financing might be needed to ensure fleet modernisation.

The observed renewal rate and condition of existing rolling stock may indeed reflect the significant costs and complexity associated with access to rolling stock. Access to passenger and tractive rolling stock seems to be particularly complex, representing a major barrier to entry and/or expansion in the corresponding segments. The main driver of this complexity is the lack of technical standardisation of rolling stock across Europe, which is the result of differences in the rail infrastructure across different Member States, and of redundant national technical/operational rules that still persist in spite of a European binding framework of Technical Specifications for Interoperability (TSI). This represents a technical barrier which prevents rolling stock from being exchanged across different countries, and therefore limits the development of a European-wide and well-functioning market where rolling stock is exchanged. This does not appear to be an issue for freight wagons, which can circulate virtually the whole European railway network; indeed, freight wagons do not need to be connected to the catenary lines and do not require particular technical characteristics to be able to circulate on different national railway networks. The only limit to their interoperability is the difference in the gauge in specific countries (such as Spain and Portugal), although modern freight wagons have a variable gauge which addresses this potential issue.

This lack of standardisation also affects the second-hand market, which is also mostly limited to a national dimension. As a result, there is a concern that rail incumbents may contribute to making access to rolling stock costlier for other market participants. Entrant railway undertakings often cannot source used rolling stock from other Member States, and incumbents are the main suppliers of used rolling stock in each country, due to the fact that prior to the liberalisation of the rail markets they were the only buyers of rolling stock.

The analyses carried out by the Consortium suggest that incumbents may have an incentive to scrap or store rolling stock which could still be used, instead of selling it or leasing it in the market. This is especially true for the passenger sector. Such behaviour would have a substantial impact on actual or potential competition only to the extent that access to second-hand rolling stock could not be effectively substituted by other sources, in particular by the option of purchasing new rolling stock or leasing rolling stock. Encouraging technical standardisation, and thus interoperability of rolling stock across the EU, seems to be of paramount importance for improving access to rolling stock for entrants, ultimately also reducing its costs. This is clearly on the Commission's agenda already: The European Rail Traffic Management System (ERTMS) entails standards for management and interoperation of signalling for railways by the European Union, which is currently one of the main obstacles to interoperability, and the development of a new TSI expected still in 2022 which aims to create technical standards that allow passenger coaches to operate on a large part of the union's standard gauge network.

Not only does the rate at which rolling stock is being replaced seem sub-optimal, but also the rate at which it is retrofitted to introduce innovative and clean technologies appears too slow. Hence, public financing could also be needed to foster the introduction of such technologies. Another advantage they bring is that they can reduce CO_2 emissions and the levels of other pollutants and railway noise, both directly and indirectly through greater efficiency in rail transport. For example, switching to clean propulsion systems has a direct impact on the reduction of emissions, while the introduction of new technological solutions can lead to an increase in the productivity of rolling stock, which reduces operating costs, fosters the modal shift to rail and ultimately leads to lower emissions.

Despite its long-term efficiency benefits, the literature reports that the costs and risks currently associated with the adoption of new and clean technologies might be incentivising undertakings to delay migration towards these technologies until their rolling stock has reached the end of its life and should be replaced anyway. One of the reasons for this is that being equipped with these technologies will bring benefits only to the extent that they are introduced at a certain scale, giving undertakings an incentive to delay the migration. Moreover, the incentives of railway undertakings and infrastructure managers are often misaligned; for the latter, the migration to certain technologies requires high investment with little to no benefit. From a policy perspective, to encourage the introduction of these technologies it might be desirable to provide EU-wide coordination, for instance by making them mandatory through an update to the relevant Technical Specifications for Interoperability, of course including an appropriate transition period. Subsidies for first-movers might also be employed if one wanted to incentivise the migration.

More generally, considering the status of the existing rolling stock fleet, subsidies aimed at encouraging the renewal of rolling stock may serve a dual goal: On the one hand, they could increase the production rate and ensure that rolling stock fleets do not shrink in the next few years; on the other, they could foster the adoption of new technologies, as there is evidence that, given the high costs related to retrofitting, railway undertakings tend to wait until the replacement time to introduce them. Nonetheless, it should be borne in mind that the railway system is interconnected, thus other forms of State aid (such as operating subsidies or investment aid for the railway infrastructure) might also make the sector more profitable and incentivise investment in the procurement of rolling stock.

Costs, revenues and profitability of rail freight services

The study presents estimates of costs, revenues and the profitability of rail transport services as reported in the stakeholder consultation, academic literature, annual company reports, industry reports and databases. The measure is Eurocent per net tonne-kilometre (cent/tkm), which tracks actual transport performance in terms of both weight and distance. As far as granular data is not available, we follow a top-down approach and use aggregated data, e.g. costs or revenues for all rail freight services of a railway undertaking on an annual level, and derive per tkm measures by dividing the total costs or revenues by freight volume.

We report the profitability of rail freight broken down by several dimensions. First, costs, revenues and the resulting profit margin of rail freight services differ between **countries** due to – among other factors - differences in geography, available infrastructure, varying labour costs, taxation and regulation, and differences in the product-mix. Reported profitability figures indicate that the rail freight sector in Italy, the Netherlands and Poland is – on average – profitable; it operates at near-zero margins or close to breaking even in the Czech Republic, Lithuania, and Spain; and it is loss-making in Austria, Germany, Romania, Slovakia, Sweden and Switzerland. Average sector profitability in a country does not imply that all rail freight services are loss-making though: RU offering specific services in those countries can still operate profitably.

The second dimension is **train type**, which for the purpose of this study is divided into three categories: block trains, single-wagon operations and intermodal transport. While the delineation between these categories is becoming increasingly blurred (e.g. use of intermodal loading units in single-wagon transport), these three categories are still widely used in the industry. Block train costs are relatively low due to economies of scale and a simple organisation. Competition from road transport is limited, but there is competitive pressure from within the rail freight sector and in some cases from water transport. Thus, block trains tend to have a small, but positive margin. Single-wagon transport is overall unprofitable: High network and investment costs paired with low utilisation rates, longer transport times and unsatisfactory reliability render it mostly uncompetitive against road and intermodal transport. However, operating single-wagonloads in specific freight segments (e.g. chemicals) or under specific circumstances (high performance infrastructure, modern rolling stock) may be profitable. The market for intermodal transport keeps growing and remains profitable, despite strong competition both within the segment and externally from road.

The third dimension is the type of railway undertaking: The costs of national rail **incumbents** tend to be higher than that of new **entrants** due to differences in operational efficiency, different mixes of freight and types of services offered. This typically leads to lower profitability for the incumbents compared to entrants.

The fourth dimension is **freight categories**. Little data is available on costs specific to particular freight categories. To the extent that there are differences in costs, these are often attributable to the train type. On the revenue side, automotive goods stand out with the highest revenue per tonne-kilometres (tkm), followed by basic metals, chemicals and coke.

The fifth dimension is **national vs. international** routes: On average higher costs (per tkm) are incurred on national routes, while revenues remain similar, rendering international rail freight transport more profitable than national. This likely stems from the longer transport distance for international routes, which drives average cost down, despite the additional costs incurred by crossing borders.

Rail freight transport benefits from economies of scale due to low variable costs and high fixed costs. Consequently, the longer the **transport distance** and the **train length** (or freight volume), the more competitive rail becomes vis-à-vis road. The larger the share of fixed costs, the greater average costs decrease with increasing distance or train length. We conduct a simulation which indicates that the average cost per tkm i) decreases by about 12% with an increase of the average transport distance (of 354 km) by an additional 100 km; ii) decreases by about 2% when another wagon is added to a train typically 28 wagons long.

The competitiveness of rail over longer distances can be stifled by inefficiencies at **national borders**. Cross-border traffic is characterised by additional costs associated with the lack of technical interoperability, additional labour cost and unharmonised regulations and standards. The extent to which costs increase depends on the technical solutions adopted to solve interoperability issues and additional labour cost due to crossing the border. At some borders the cost increase is negligible as there is no change in gauge, traction current and language. However, at others, the cost of crossing a border, converted to cents per tkm, is significant, at 5% relative to an otherwise identical inland transport of the same distance for a medium-difficult border, like Spain-Portugal, with a different traction current and language; around 20% for Lithuania-Poland; and between 38% - 73% for the border Spain-France, where the crossing includes a change in gauge in addition to traction current and language differences. Alongside these factors, there is the additional complexity of cooperating with multiple infrastructure managers, rolling stock providers and regulatory regimes, all of which can discourage railway undertakings from offering cross-border services.

The data collected for **intermodal transport** shows that, out of the three types of intermodal transport (short sea/road, inland waterway/road, rail/road), IWW/road has the lowest costs per Loading Unit (LU), while SSS/road is the most expensive mode of transport. Rail/road intermodal transport falls in the middle. Considering that there are significant differences in average distance of different modes of transport and taking them into account by calculating a EUR/tkm measure, the the opposite cost ranking emerges: SSS transport appears to be the cheapest mode, followed by rail/road, while IWW/road is the most expensive.

Intermodal transport is profitable, but little information is available on profit margins. Responses to the stakeholder consultation, triangulated with the literature, indicate a potential range of 2-20%. The crucial factor for profitability in intermodal rail/road transport is the length of the main leg versus the initial/final road legs. For short sea/road and inland waterway/road, the most relevant factor for profitability is instead the volume of freight.

The data collected for **accompanied intermodal transport** shows that it is significantly more costly than unaccompanied intermodal transport. This is due to the technical constraints of accompanied trains, which carry fewer loading units and more weight than unaccompanied transport (since their weight also includes the tractor unit of the truck).

The range of reported **break-even** or **minimum competitive distances** is wide: Most sources point to a break-even distance, from which rail operations become profitable or competitive aganst road transport, of between 100 and 600km, but distances outside this range are also quoted. This depends on a number of factors. High freight volumes and shuttle frequencies, e.g. between industrial hubs and deep-sea ports, can potentially make even short distances profitable. High-value cargo or goods that are required to be transported by rail, e.g. certain chemical goods, can be transported profitably across small distances. Furthermore, in the case of intermodal transport, efficient transshipment, e.g. modern terminals, and efficient last mile transport, improve the competitiveness of rail, thus decreasing the minimum competitive distance. Lastly, the timeliness of the service relevant: If the rail infrastructure is congested and timetables are not met, the minimum competitive distance increases.

The study also addresses the **price elasticity of demand**, which measures how demand varies with changes in prices for rail freight. Elasticity estimates were mainly collected from the available published literature and non-public research reports provided by institutions and authorities, supported by a small number of responses in the stakeholder consultation. These estimates suggest that price elasticities for bulk goods tend to be low. Likewise demand for block trains is mostly inelastic. The evidence suggests that, in many cases, State aid for these segments might not be well-targeted. Elasticities for other freight categories, single-wagon and intermodal transport tend to be higher. This is likely due to strong competition from road, among other factors. When aiming for a modal shift, the evidence indicates that State aid in these segments could prove helpful in increasing transport volume on rail.

Design of State aid for rail freight

The study also investigated selected features of the State aid design in rail freight: Types of State aid addressing structurally loss-making rail freight services; thresholds for aid intensity to consider State aid necessary and proportional; design of schemes for start-ups, pass-through of aid granted to railway undertakings and the efficiency of State aid directed to end-users and to railway undertakings.

First, single-wagon transport has the potential to shift transport volumes from road to rail, especially in situations where intermodal transport is not a viable alternative. Notwithstanding this potential, a significant amount of State aid is likely required to make it competitive in most scenarios. Austrian rail exemplifies that subsidies can be effective in maintaining sizeable single-wagon operations. Complementarily, governments could attempt to foster investment in infrastructure or rolling stock to improve conditions for RU that conduct single-wagon transport.

Another service unable to exist without subsidies is accompanied intermodal transport. State aid is granted to operators of such services in Austria, Romania and Switzerland, to compensate their higher cost compared to road. Indeed, hauliers can be attracted to accompanied transport services only if lower prices and shorter transport time are offered to them as compared to transport by road.

Second, the study assessed the aid intensity thresholds for the presumption of necessity and proportionality. Stakeholders indicated that to incentivise railway undertakings to shift traffic from road to rail, 30% of total costs is too low a threshold for assuring the proportionality and necessity of State aid. An example mentioned in the replies is that, in some countries, track access charges alone represent 30% of the total costs of rail freight transport. Higher thresholds, e.g. between 50% and 60% as suggested by a stakeholder, could incentivise stakeholders to develop rail freight or intermodal services. Moreover, stakeholders indicated that the threshold for total cost needs to be increased if the threshold for aid for the reduction of external costs is increased significantly. Since both these thresholds constrain the amount of State aid that can be granted under the assumption of necessity and proportionality, increasing one threshold without adjusting the second one would hamper the overall effectiveness of State aid to rail freight.

The study also examined the relationship between the additional cost of rail transport compared to road transport on the one hand, and half of the additional external cost of road transport compared to rail transport (the eligible cost) on the other hand. For the majority of Members States with available data, State aid compensating for half of the external cost (50%) differential between the two modes of transport would not be enough to make rail freight services competitive vis-à-vis road freight services. Conversely, in the Czech Republic, Lithuania, Poland and Spain, the difference in total costs between rail and road is approximately equal to half of the external cost differential between the two modes of transport. State aid covering eligible costs could thus bridge the cost gap between the two types of transport in those countries.

Third, several Member States have offered State aid schemes for start-ups in innovative intermodal transport services. Experiences with these schemes suggest that lack of flexibility in terms of scheme duration, type of services and aid intensity can render a scheme failure. Member States have also offered State aid schemes to reduce the cost of access to infrastructure, for example by offering track access price reductions. Some of these schemes were introduced as a reaction to the COVID-19 pandemic. Publicly available ex-post analysis was available for two schemes, which was positive: The schemes have increased the rail freight volume.

Fourth, the study reviewed existing evidence of the impact of State aid schemes on rail freight market. Descriptive evidence suggests that there is a partial pass-through of State aid in cases where aid is not paid directly to the end user. Evidence also indicates that increases in road haulage costs to encourage modal shift, which can be viewed as the inverse of State support, are only passed to end users by larger hauliers with bargaining power. The setting-in-place of accounting requirements for full or proportionate pass-through of State aid can be seen as an imperfect mechanism to facilitate at least partial pass-through of support. However, evidence from passenger transport indicates that price reductions for end users may be compensated with higher pre-subsidy prices compared to non-subsidised services.

Ex-post evaluations for State aid schemes in rail freight are rare, which makes it difficult to compare effectiveness and efficiency of schemes targeted to rail service users (demand side) with schemes targeted to railway undertakings (supply side). The evaluation of the Italian schemes *Ferrobonus* and *Ecobonus* targeted to final users found their significant positive effect on the modal shift volume. The evaluation of the Austrian schemes for railway undertakings *Aid for innovative combined transport* concluded that they achieved a modal shift of up to 36% in tkm countrywide. The evidence in these evaluations is of purely descriptive nature. No comparable evidence of efficiency of these schemes is available. The introduction of the requirement to evaluate schemes in the new railway guidelines, as it is the case in other State aid guidelines, could facilitate the generation of evidence and allow for better informed decisions on State aid scheme design in the future.

Trade-offs exist between State aid's potential to facilitate modal shift and the risk to distort competition. State aid for rail operations can be expected to reduce operating costs in the short term. Compared to investment aid, operating State aid has a higher potential to distort competition within the rail freight segment, but it can also facilitate a modal shift to rail in the short term. Investment State aid for infrastructure and rolling stock can be expected to reduce operating costs in the long-term by increasing capacity and supporting the use of modern and efficient technical solutions. Compared to operating State aid, such aid would be less likely to distort competition within the rail freight segment, but it would take longer to facilitate a modal shift to rail.

Résumé

Longtemps à la frontière de la logistique du transport de marchandises, le rail a perdu sa position dominante au profit du transport routier. Bien que le transport ferroviaire reste compétitif dans certains segments, sa part modale du transport de marchandises en Europe n'a cessé de diminuer au cours de la seconde moitié du 20e siècle. Ce déclin s'explique par plusieurs raisons, notamment la réorientation structurelle de l'économie vers les industries lourdes, qui a entraîné une demande de solutions de transport routier plus flexibles, des investissements à grande échelle dans les infrastructures routières et des innovations dans la logistique routière. La libéralisation des secteurs nationaux du fret ferroviaire en Europe au cours des deux dernières décennies n'a pas été suffisante pour inverser cette tendance.

Dans le cadre du "Green Deal" européen, l'Union européenne (UE) vise à doubler le trafic de fret ferroviaire d'ici 2050. La révision des lignes directrices communautaires actuelles sur les aides d'État aux entreprises ferroviaires (Lignes directrices sur les chemins de fer, LD) vise à soutenir la réalisation de cet objectif ambitieux. La Direction générale de la concurrence de la Commission européenne (DG COMP) a chargé le consortium composé de E.CA Economics, LEAR, Sheppard Mullin et UEA (le Consortium), soutenu par l'Institute for Transport Studies de l'Université de Leeds, de réaliser une étude externe pour soutenir la révision du RG. Cette étude fournit des informations détaillées sur le marché, basées sur des recherches documentaires et la collecte de données, y compris une consultation ciblée des parties prenantes, afin d'informer le processus de révision du RG. L'étude aborde les sujets suivants. i) vue d'ensemble des aides d'État et autres mesures de soutien public au transport ferroviaire de marchandises ; ii) infrastructure ferroviaire, y compris les embranchements privés ; iii) modernisation et accès au matériel roulant ; iv) coût, revenu et rentabilité des services de fret ferroviaire et du transport intermodal ainsi que l'élasticité de la demande de services de fret ferroviaire par rapport au prix. Enfin, l'étude fournit des conclusions sur la conception des aides d'État pour le fret ferroviaire.

Le secteur du fret ferroviaire diffère considérablement d'un pays européen à l'autre. En 2019, dernière année précédant la pandémie, la part modale du rail (basée sur le volume de transport de la route, du rail, du transport fluvial et du transport maritime à courte distance en tonnes) variait d'une moyenne de 4,1 % dans les pays d'Europe du Sud à 14,5 % en Europe de l'Est. Les cinq principaux types de marchandises transportées par le rail comprenaient les marchandises conteneurisées, les minerais métalliques, le coke, le charbon et les métaux de base. Ensemble, ils représentaient environ 67% du volume total de fret ferroviaire dans l'UE. Hormis les marchandises conteneurisées, ces types de fret sont généralement transportés par des trains complets. Le transport intermodal, qui utilise des unités de chargement intermodales telles que des conteneurs et des caisses mobiles, est un segment en pleine croissance dans le secteur du fret ferroviaire. Sa part dans le transport ferroviaire total varie considérablement d'un pays à l'autre, allant de 1,4 % en Lettonie à 80 % en Grèce. Les opérations par wagon unique sont en déclin, voire ne sont plus proposées dans plusieurs États membres. Dans toute l'Europe, la distance moyenne parcourue par une tonne de fret à l'intérieur d'un pays variait de 43 km à 415 km, avec une moyenne de 241 km. La structure du marché du fret ferroviaire a également beaucoup varié. La part de l'opérateur historique en 2019 s'étendait de 0 % à plus de 90 %.

Aperçu des aides d'État dans le secteur du fret ferroviaire

Afin de mieux comprendre la nature des mesures de soutien public aux services intermodaux et au fret ferroviaire, une base de données de 156 décisions pertinentes de la Commission européenne (CE) en matière d'aides d'État a été compilée à partir de la base de données de recherche de cas de la Commission européenne et complétée par des recherches documentaires supplémentaires afin de déterminer les mesures de soutien public en Suisse et les aides qui ne sont pas des aides d'État.

Nous avons identifié 104 mesures d'aide d'État soutenant le fret ferroviaire et le transfert modal du trafic de marchandises de la route vers des modes de transport plus respectueux de l'environnement (rail, voies navigables intérieures et maritimes). Les régimes sont devenus nettement plus populaires au fil du temps. Nous avons observé 34 régimes en opération en 2012 et 64 régimes en opération en 2021, avec un budget total de 338,06 millions d'euros en 2012 et de 2,29 milliards d'euros en 2021.

On constate également une grande diversité, tant dans le type de régime que dans les modes de transport soutenus. Dans l'ensemble de l'échantillon, nous avons identifié 88 mesures soutenant le secteur du transport ferroviaire de marchandises, 58 mesures soutenant l'infrastructure intermodale, 15 mesures soutenant le secteur maritime et 31 mesures liées au secteur de la navigation intérieure. Nous avons également identifié une diversité importante au sein des types de mesures, soutenant une grande variété de projets et de bénéficiaires différents. Par exemple, dans le secteur du transport ferroviaire de marchandises, bien que nous observions principalement des régimes ouverts aux opérateurs de fret ferroviaire et aux propriétaires de terminaux, nous avons également observé une petite minorité de régimes qui étaient ouverts à d'autres bénéficiaires, tels que les installations de recherche et les producteurs de matériel roulant.

Le niveau global des aides d'État à l'exploitation par tkm approuvées par la Commission européenne en 2019 - soit la dernière année précédant la pandémie - était insignifiant pour la plupart des États membres. Les exceptions notables sont l'Autriche (0,71 ct/km) et l'Italie (0,48 ct/km), la première maintenant effectivement les opérations par wagon unique et le transport intermodal accompagné sur le marché, et la seconde ayant des difficultés à favoriser la part modale du fret ferroviaire, malgré un niveau relativement élevé d'aides d'État à l'exploitation. En 2019, la République tchèque, la Lituanie et la Pologne n'ont pas déclaré d'aide d'État à l'exploitation du fret ferroviaire pour cette année-là. Cela n'exclut pas que des aides d'État aient été accordées à des intensités inférieures aux niveaux requis pour la notification.

Pour évaluer l'efficacité des mesures pour soutenir un transfert modal de la route vers le rail et d'autres modes de transport plus respectueux de l'environnement, la base de données est mise en correspondance avec des informations financières sur les dépenses prévues et/ou réelles et des données sur les parts modales. Ces données montrent que la part du fret transporté par les modes de transport prioritaires pour le soutien de l'État a diminué, mais que le niveau réel du volume total du transport ferroviaire (en tonnes) a augmenté entre 2012 et 2019.

L'évolution des parts modales varie considérablement d'un État membre à l'autre. Avec des parts combinées du rail, de la navigation intérieure (IWW) et du transport maritime à courte distance (SSS) dépassant 45 % des tonnes de fret, la Lettonie et la Lituanie ont connu une baisse combinée des parts du non-routier en tonnes qui a dépassé 10 points de pourcentage entre 2012 et 2019. Des augmentations modestes des parts modales non routières entre 2012 et 2019 ont été constatées pour la combinaison du rail, de la navigation intérieure et du TMCD, entre 1 et 7 points de pourcentage de tonnes pour la Bulgarie, la Grèce, la Finlande, le Portugal, l'Irlande, la France, le Danemark et la Suisse. Le nombre de régimes de soutien public au transport non routier et le montant du financement accordé varient en Europe. Certains pays dont la part modale du rail, de la voie navigable et du TMCD est élevée (ou dont l'évolution de cette part est relativement importante) n'ont aucun régime, tandis que d'autres pays dont la part modale du rail, de la voie navigable et du TMCD est faible (ou dont l'évolution de cette part est relativement faible) ont plusieurs régimes. En raison de la complexité des facteurs affectant le transport et de la rareté des données disponibles, il est difficile d'identifier exactement ceux qui influent sur les changements de part modale. Les corrélations entre le soutien de l'État et la part modale du rail/des voies ferrées/du SSS, ainsi que la corrélation entre les changements de ces deux variables, sont faiblement négatives. Toutefois, l'absence de corrélation ferme à un niveau agrégé ne signifie pas que les régimes spécifiques n'ont aucun effet. Des entretiens plus ciblés sur le plan géographique et temporel peuvent indiquer le contraire, comme dans le cas de l'inversion d'une baisse de la part du rail apparemment due à la construction d'un nouveau terminal au Luxembourg.

L'infrastructure ferroviaire

L'infrastructure ferroviaire européenne est un système complexe, comprenant des réseaux ferroviaires nationaux avec différents types d'installations de service et de terminaux intermodaux, ainsi que des voies d'évitement privées. Chaque partie est complémentaire de l'autre. Il faut donc comprendre qu'un goulet d'étranglement à un niveau du système d'infrastructure peut créer des perturbations à d'autres niveaux, et pourrait entraver l'objectif du transfert modal. Par conséquent, pour que le trafic ferroviaire plus intense puisse être desservi sans causer de retard, l'ensemble de l'infrastructure ferroviaire doit non seulement être capable de gérer la charge de travail actuelle, mais aussi de répondre à une demande accrue.

L'analyse des données accessibles au public sur le nombre d'installations pour le transport ferroviaire indique que dans certains pays, les installations existantes pourraient être insuffisantes pour satisfaire même le niveau actuel de la demande. La densité des installations de service, en particulier, a été analysée. Des installations plus dispersées peuvent augmenter les coûts associés au transport ferroviaire, à la fois en raison du temps plus long nécessaire pour atteindre les installations, et en raison des risques plus élevés de congestion. Cependant, une analyse de la densité ne peut que donner une idée partielle de la situation, car elle ne tient pas compte de la capacité des installations. Sur ce point, les régulateurs de marché qui ont répondu aux enquêtes des parties prenantes ont indiqué qu'en général, les installations garantissent une bonne disponibilité des services fournis.

Il ressort des entretiens menés par le Consortium que les parties prenantes concernées considèrent que le nombre d'installations essentielles en Europe est insuffisant, tant en termes de nombre que de capacité. La part de marché pour la fourniture de services est biaisée en faveur des opérateurs historiques verticalement intégrés, ce qui peut leur donner la possibilité de discriminer les autres participants au marché. Bien que l'accès aux services fournis par ces installations doive être assuré de manière non discriminatoire conformément à la directive 2012/34, cette obligation peut être difficile à contrôler pour les autorités nationales en raison des nombreux facteurs qui affectent la capacité réelle des entreprises ferroviaires (EF) à y accéder (tels que la capacité maximale de l'installation, l'efficacité des services offerts et le temps réel nécessaire aux opérations).

Le Consortium a également examiné l'adéquation des terminaux intermodaux. Tant l'analyse des données publiques que la littérature existante indiquent un manque de terminaux intermodaux en Europe. Dans de nombreux pays, les terminaux intermodaux semblent être surchargés, c'est-à-dire qu'ils doivent gérer plus de fret que ce qui est optimal, ce qui pourrait entraîner des retards et des annulations de trains. Alors que certains gestionnaires de terminaux intermodaux interrogés par le Consortium ont souligné que les terminaux fonctionnent de manière rentable, et que s'il y avait une demande excédentaire à satisfaire, davantage de terminaux seraient construits, il convient de noter qu'il existe un certain degré d'hétérogénéité dans le nombre (et le type) de terminaux intermodaux dans les régions. En effet, il est probable que si les terminaux intermodaux qui ont été analysés pour les études de cas sont rentables et capables et désireux d'augmenter leur capacité, d'autres terminaux intermodaux situés ailleurs pourraient ne pas l'être ; de plus, il pourrait y avoir un manque de types spécifiques de terminaux intermodaux (tels que les terminaux routiers/internationaux/maritimes), comme l'ont souligné certains participants à l'enquête auprès des parties prenantes.

Enfin, les gestionnaires de terminaux intermodaux, ainsi que les parties prenantes interrogées dans le cadre de l'étude, comme l'European Rail Freight Association (ERFA), l'Alliance of Passenger Rail New Entrants in Europe (ALLRAIL) et la Communauté européenne des chemins de fer et des sociétés d'infrastructure (CER), ont souligné que le réseau ferroviaire existant en Europe est encombré et n'est pas adapté à l'exploitation de trains plus nombreux et plus longs. Cette affirmation a également été soutenue par un expéditeur interrogé par le Consortium.

Les preuves recueillies suggèrent que ces deux problèmes affectent la capacité de l'infrastructure ferroviaire européenne. Il se peut qu'il y ait un manque de terminaux intermodaux dans certains pays, mais cela n'exclut pas la possibilité que le réseau ferroviaire existant soit encombré. Le fait que les terminaux puissent manquer dans certaines régions est probablement dû aux faibles rendements que l'investissement pourrait assurer. Les terminaux déficitaires pourraient avoir besoin d'un soutien pour rester en activité, bien qu'ils augmentent le choix des expéditeurs et la connexion au réseau ferroviaire national, réduisant ainsi les externalités négatives causées par le transport routier, permettant éventuellement d'utiliser davantage les différentes parties des réseaux, et redirigeant le trafic des zones encombrées. Si l'on voulait promouvoir le transport intermodal, il faudrait envisager le compromis entre un réseau de terminaux intermodaux plus dense et le coût de leur entretien.

Le réseau ferroviaire existant n'est pas détenu et exploité exclusivement par les gestionnaires d'infrastructure. Les embranchements privés sont des voies ferrées privées qui relient les points de chargement (par exemple, les installations industrielles ou les entrepôts) au réseau ferroviaire principal, ce qui permet aux entreprises d'éviter le transport routier pour le premier et/ou le dernier kilomètre. En transportant les marchandises directement entre l'infrastructure ferroviaire publique et leurs propres locaux, les entreprises peuvent réduire l'exposition aux perturbations logistiques telles que la pénurie de conducteurs ou la congestion des routes. La plupart des transports ferroviaires de marchandises en Europe passent au moins une partie de leur trajet sur des voies d'évitement privées. Cela inclut près de 85% des volumes de transport en Allemagne, environ 60% en Autriche et 70% en Slovaquie. Si l'on veut promouvoir le transfert modal vers le rail, les embranchements pourraient donc jouer un rôle central. Cependant, il semble que le nombre de voies d'évitement privées diminue de manière générale en Europe ; par exemple, en Allemagne, le nombre de voies d'évitement est passé d'environ 13 000 en 1993 à 1 300 en 2013, tandis qu'en Autriche, il est passé de 840 en 2010 à 521 en 2020.

Malgré les avantages que peuvent offrir les embranchements privés, les solutions de transport routier sont généralement moins chères à court terme (et éventuellement à long terme, à moins d'atteindre un certain seuil de marchandises transportées) et sont donc parfois encore préférées par les entreprises privées. D'une manière générale, les embranchements constituent un investissement dont la durée de vie utile technique est longue (environ 30 ans, selon une réponse à l'enquête auprès des parties prenantes). Néanmoins, la durée de vie utile économique peut être réduite en raison du risque que la voie de garage ne soit plus desservie à l'avenir.

Lorsqu'on se demande s'il faut soutenir le développement de nouvelles voies d'évitement privées, les facteurs qui influencent l'analyse de rentabilité sont pertinents. En effet, si les régimes de subventions directes (comme ceux qui existent déjà, entre autres, en Autriche et en Allemagne), visant à réduire directement les coûts de construction, constituent une solution possible, il convient d'examiner comment les différents facteurs (par exemple, le fret transporté et la longueur de la voie d'évitement) influent sur l'analyse de rentabilité de la construction d'une voie d'évitement. Le développement de nouvelles voies d'évitement pourrait également être encouragé par d'autres politiques, qui tirent parti de l'interaction entre la voie d'évitement et l'infrastructure ferroviaire. Par exemple, l'augmentation de la densité du réseau ferroviaire pourrait réduire la longueur d'une voie de garage, et donc le coût de construction et le déficit de financement. Les subventions directes et les autres options politiques pourraient être combinées si l'une d'entre elles visait à favoriser le développement de nouvelles voies d'évitement.

Matériel roulant

Le contrôle d'aptitude des lignes directrices pour les chemins de fer effectué entre 2019 et 2020 par la Commission européenne a fait apparaître une inquiétude quant à la vétusté du matériel roulant dans l'UE.

La littérature montre qu'en 2019, plus de 50 % du parc de wagons de marchandises en Europe avait plus de 30 ans, la même source estimant sa durée de vie utile moyenne entre 35 et 50 ans. L'analyse des registres nationaux de véhicules montre que la situation ne semble pas s'être améliorée au cours des trois dernières années. Le matériel roulant pour passagers est, en moyenne, encore plus vieux que le matériel roulant pour marchandises, tandis que le matériel roulant de traction est en moyenne plus jeune. Les locomotives de manœuvre et diverses (par exemple, les locomotives à vapeur), qui ont en moyenne près de 40 ans, constituent une exception. Un facteur qui pourrait contrecarrer l'objectif de la stratégie de mobilité durable et intelligente de l'UE, qui consiste à doubler le transport ferroviaire de marchandises d'ici 2050, est qu'au rythme actuel de renouvellement, le secteur se dirige vers une réduction nette de la taille de la flotte. Cela est dû au fait qu'une forte proportion du parc de matériel roulant approche de la fin de sa vie utile, et il semble peu probable qu'il existe actuellement une capacité de réserve suffisante pour satisfaire l'augmentation souhaitée des volumes. Bien que ce problème puisse être partiellement atténué par la modernisation du vieux matériel roulant, cela ne suffira probablement pas à inverser la réduction des flottes.

Le Consortium a étudié les causes de cette situation, et en particulier les contraintes qui pèsent sur la capacité des entreprises ferroviaires à investir dans le réaménagement ou le remplacement du matériel roulant. Nous avons constaté que les contraintes sont principalement d'ordre financier et que les petits opérateurs en particulier peuvent ne pas avoir accès au crédit à des conditions compétitives. Cela pourrait également conduire les petites entreprises à utiliser du matériel roulant économiquement obsolète, c'est-à-dire du matériel roulant dont les coûts d'exploitation sont plus élevés et qu'il serait plus rentable de remplacer ou de réaménager. Ces contraintes financières peuvent également générer un avantage concurrentiel pour les entreprises ferroviaires d'État ; ces dernières peuvent être en mesure d'accéder au crédit à de meilleures conditions grâce à des garanties d'État implicites ou explicites. Si l'on constate une augmentation constante du niveau de financement privé depuis 2011, on observe une certaine hétérogénéité entre les segments du marché, les segments plus libéralisés affichant une plus forte concentration de financement privé. Ainsi, étant donné l'état du parc de matériel roulant en Europe, et son taux de renouvellement sous-optimal, un financement public pourrait être nécessaire pour assurer la modernisation du parc.

Le taux de renouvellement observé et l'état du matériel roulant existant peuvent en effet refléter les coûts importants et la complexité associés à l'accès au matériel roulant. L'accès au matériel roulant de transport de passagers et de traction semble être particulièrement complexe, représentant une barrière majeure à l'entrée et/ou à l'expansion dans les segments correspondants. Le principal moteur de cette complexité est le manque de normalisation technique du matériel roulant en Europe, qui résulte des différences d'infrastructure ferroviaire entre les différents États membres et des règles techniques/opérationnelles nationales redondantes qui persistent malgré un cadre européen contraignant de spécifications techniques d'interopérabilité (STI). Cela représente une barrière technique qui empêche le matériel roulant d'être échangé entre différents pays, et limite donc le développement d'un marché paneuropéen performant où le matériel roulant est échangé. Cela ne semble pas être un problème pour les wagons de marchandises, qui peuvent circuler sur la quasi-totalité du réseau ferroviaire européen ; en effet, les wagons de marchandises n'ont pas besoin d'être connectés aux lignes caténaires et ne nécessitent pas de caractéristiques techniques particulières pour pouvoir circuler sur différents réseaux ferroviaires nationaux. La seule limite à leur interopérabilité est la différence d'écartement dans certains pays (comme l'Espagne et le Portugal), bien que les wagons de fret modernes disposent d'un écartement variable qui résout ce potentiel problème.

Ce manque de normalisation affecte également le marché de l'occasion, qui se limite aussi le plus souvent à une dimension nationale. Par conséquent, on craint que les entreprises ferroviaires historiques ne contribuent à rendre l'accès au matériel roulant plus coûteux pour les autres acteurs du marché. Les entreprises ferroviaires entrantes ne peuvent souvent pas s'approvisionner en matériel roulant usagé auprès d'autres États membres, et les opérateurs historiques sont les principaux fournisseurs de matériel roulant usagé dans chaque pays, du fait qu'avant la libéralisation des marchés ferroviaires, ils étaient les seuls acheteurs de matériel roulant.

Les analyses effectuées par le Consortium suggèrent que les opérateurs historiques peuvent être incités à mettre à la casse ou à stocker le matériel roulant qui pourrait encore être utilisé, au lieu de le vendre ou de le louer sur le marché. Ceci est particulièrement vrai pour le secteur du transport de passagers. Un tel comportement n'aurait un impact substantiel sur la concurrence réelle ou potentielle que dans la mesure où l'accès au matériel roulant d'occasion ne pourrait pas être efficacement remplacé par d'autres sources, notamment par la possibilité d'acheter du matériel roulant neuf ou de le louer. Encourager la normalisation technique, et donc l'interopérabilité du matériel roulant dans l'ensemble de l'UE, semble être d'une importance capitale pour améliorer l'accès au matériel roulant pour les nouveaux entrants et, en fin de compte, réduire également ses coûts. Cet aspect figure déjà clairement à l'ordre du jour de la Commission. Le système européen de gestion du trafic ferroviaire (ERTMS) implique des normes pour la gestion et l'interopérabilité de la signalisation des chemins de fer de l'Union européenne, qui est actuellement l'un des principaux obstacles à l'interopérabilité, et le développement d'une nouvelle STI attendue toujours en 2022 qui vise à créer des normes techniques permettant aux autocars de passagers de circuler sur une grande partie du réseau à écartement normal de l'Union.

Non seulement le rythme auquel le matériel roulant est remplacé semble sous-optimal, mais le rythme auquel il est réaménagé pour introduire des technologies innovantes et propres semble également trop lent. Par conséquent, un financement public pourrait également être nécessaire pour favoriser l'introduction de ces technologies. Un autre avantage qu'elles apportent est qu'elles peuvent réduire les émissions de CO2 et les niveaux d'autres polluants ainsi que le bruit ferroviaire, à la fois directement et indirectement grâce à une plus grande efficacité du transport ferroviaire. Par exemple, le passage à des systèmes de propulsion propres a un impact direct sur la réduction des émissions, tandis que l'introduction de nouvelles solutions technologiques peut conduire à une augmentation de la productivité du matériel roulant, ce qui réduit les coûts d'exploitation, favorise le transfert modal vers le rail et conduit finalement à une réduction des émissions.

Nonobstant ses avantages en termes d'efficacité à long terme, la littérature rapporte que les coûts et les risques actuellement associés à l'adoption de technologies nouvelles et propres pourraient inciter les entreprises à retarder la migration vers ces technologies jusqu'à ce que leur matériel roulant ait atteint la fin de sa vie et doive être remplacé de toute façon. L'une des raisons en est que le fait d'être équipé de ces technologies n'apportera des avantages que dans la mesure où elles sont introduites à une certaine échelle, ce qui incite les entreprises à retarder la migration. En outre, les incitations des entreprises ferroviaires et des gestionnaires de l'infrastructure sont souvent mal alignées ; pour ces derniers, la migration vers certaines technologies nécessite des investissements élevés pour des bénéfices faibles ou nuls. D'un point de vue politique, pour encourager l'introduction de ces technologies, il pourrait être souhaitable de prévoir une coordination à l'échelle de l'UE, par exemple en les rendant obligatoires par une mise à jour des spécifications techniques d'interopérabilité pertinentes, en prévoyant bien sûr une période de transition appropriée. Des subventions pour les premiers arrivés pourraient également être utilisées si l'on voulait encourager la migration.

Plus généralement, compte tenu de l'état du parc de matériel roulant existant, les subventions visant à encourager le renouvellement du matériel roulant pourraient servir un double objectif. D'une part, elles pourraient augmenter le taux de production et garantir que les parcs de matériel roulant ne diminuent pas au cours des prochaines années ; d'autre part, elles pourraient favoriser l'adoption de nouvelles technologies, car il est prouvé que, compte tenu des coûts élevés liés à la modernisation, les entreprises ferroviaires ont tendance à attendre le moment du remplacement pour les introduire. Néanmoins, il convient de garder à l'esprit que le système ferroviaire est interconnecté, de sorte que d'autres formes d'aides d'État (telles que les subventions d'exploitation ou les aides à l'investissement pour l'infrastructure ferroviaire) pourraient également rendre le secteur plus rentable et inciter à investir dans l'acquisition de matériel roulant.

Coûts, recettes et rentabilité des services de fret ferroviaire

L'étude présente des estimations des coûts, des recettes et de la rentabilité des services de transport ferroviaire telles qu'elles ressortent de la consultation des parties prenantes, de la littérature universitaire, des rapports annuels des entreprises, des rapports sectoriels et des bases de données. La mesure est le centime d'euro par tonne-kilomètre nette (cent/tkm), qui permet de suivre les performances réelles du transport en termes de poids et de distance. Dans la mesure où des données granulaires ne sont pas disponibles, nous suivons une approche descendante et utilisons des données agrégées, par exemple les coûts ou les recettes de tous les services de fret ferroviaire d'une entreprise ferroviaire au niveau annuel, et nous obtenons des mesures par tkm en divisant les coûts ou les recettes totales par le volume de fret.

Nous rapportons la rentabilité du fret ferroviaire ventilée selon plusieurs dimensions. Tout d'abord, les coûts, les recettes et la marge bénéficiaire résultante des services de fret ferroviaire varient d'un pays à l'autre en raison, entre autres, des différences géographiques, de l'infrastructure disponible, des coûts de main-d'œuvre variables, de la fiscalité et de la réglementation, ainsi que des différences dans la composition des produits. Les chiffres de rentabilité déclarés indiquent que le secteur du fret ferroviaire est - en moyenne - rentable en Italie, aux Pays-Bas et en Pologne ; il fonctionne avec des marges proches de zéro ou proches du seuil de rentabilité en République tchèque, en Lituanie et en Espagne ; et il est déficitaire en Autriche, en Allemagne, en Roumanie, en Slovaquie, en Suède et en Suisse. La rentabilité moyenne du secteur dans un pays ne signifie pas pour autant que tous les services de fret ferroviaire sont déficitaires. Les EF offrant des services spécifiques dans ces pays peuvent encore opérer de manière rentable.

La deuxième dimension est la typologie de trains, qui, aux fins de cette étude, est divisé en trois catégories. Trains complets, exploitation de wagons individuels et transport intermodal. Bien que la délimitation entre ces catégories soit de plus en plus floue (par exemple, l'utilisation d'unités de chargement intermodales dans le transport par wagon unique), ces trois catégories sont encore largement utilisées dans l'industrie. Les coûts des trains complets sont relativement faibles en raison des économies d'échelle et d'une organisation simple. La concurrence du transport routier est limitée, mais il existe une pression concurrentielle au sein du secteur du fret ferroviaire et, dans certains cas, du transport aquatique. Ainsi, les trains complets ont tendance à avoir une marge faible, mais positive. Le transport par wagon isolé est globalement peu rentable. Les coûts élevés de réseau et d'investissement, associés à de faibles taux d'utilisation, des temps de transport plus longs et une fiabilité insatisfaisante, le rendent peu compétitif par rapport au transport routier et intermodal. Toutefois, l'exploitation de wagons isolés dans des segments de fret spécifiques (par exemple, les produits chimiques) ou dans des circonstances particulières (infrastructure performante, matériel roulant moderne) peut être rentable. Le marché du transport intermodal ne cesse de croître et reste rentable, malgré une forte concurrence au sein du segment et en dehors de la route.

La troisième dimension est le type d'entreprise ferroviaire: les coûts des entreprises ferroviaires nationales historiques ont tendance à être plus élevés que ceux des nouveaux entrants en raison des différences d'efficacité opérationnelle, des différentes combinaisons de fret et des types de services offerts. Cela conduit généralement à une rentabilité plus faible pour les opérateurs historiques par rapport aux nouveaux entrants.

La quatrième dimension est celle des catégories de fret. Peu de données sont disponibles sur les coûts spécifiques à des catégories de fret particulières. Dans la mesure où il existe des différences de coûts, celles-ci sont souvent imputables au type de train. En ce qui concerne les recettes, les produits automobiles se distinguent par les recettes les plus élevées par tonne-kilomètre (tkm), suivis des métaux de base, des produits chimiques et du coke.

La cinquième dimension est celle des liaisons nationales par rapport aux liaisons internationales: en moyenne, les coûts (par tkm) sont plus élevés sur les itinéraires nationaux, alors que les recettes restent similaires, ce qui rend le transport ferroviaire international de marchandises plus rentable que le national. Cela s'explique probablement par la distance de transport plus longue pour les itinéraires internationaux, qui fait baisser le coût moyen, malgré les coûts supplémentaires engendrés par le passage des frontières.

Le transport ferroviaire de marchandises bénéficie d'économies d'échelle en raison des faibles coûts variables et des coûts fixes élevés. Par conséquent, plus la distance de transport et la longueur du train (ou le volume de fret) sont importantes, plus le rail devient compétitif par rapport à la route. Plus la part des coûts fixes est importante, plus les coûts moyens diminuent avec l'augmentation de la distance ou de la longueur du train. Nous effectuons une simulation qui indique que le coût moyen par tkm i) diminue d'environ 12 % avec une augmentation de la distance moyenne de transport (de 354 km) de 100 km supplémentaires ; ii) diminue d'environ 2 % lorsqu'un wagon supplémentaire est ajouté à un train généralement long de 28 wagons.

La compétitivité du rail sur les longues distances peut être étouffée par les inefficacités aux frontières nationales. Le trafic transfrontalier se caractérise par des coûts supplémentaires liés au manque d'interopérabilité technique, au coût supplémentaire de la main-d'œuvre et à des réglementations et normes non harmonisées. L'ampleur de l'augmentation des coûts dépend des solutions techniques adoptées pour résoudre les problèmes d'interopérabilité et du coût supplémentaire de la main-d'œuvre dû au passage de la frontière. À certaines frontières, l'augmentation des coûts est négligeable car il n'y a pas de changement de gabarit, de courant de traction et de langue. Cependant, à d'autres, le coût du passage d'une frontière, converti en centimes par tkm, est significatif. 5 % par rapport à un transport terrestre identique de même distance pour une frontière moyennement difficile, comme Espagne-Portugal, avec un courant de traction et une langue différents; environ 20 % pour Lituanie-Pologne ; et entre 38 % et 73 % pour la frontière Espagne-France, où le passage comprend un changement de gabarit en plus des différences de courant de traction et de langue. À ces facteurs s'ajoute la complexité supplémentaire de la coopération avec de multiples gestionnaires d'infrastructure, fournisseurs de matériel roulant et régimes réglementaires, autant de facteurs qui peuvent décourager les entreprises ferroviaires d'offrir des services transfrontaliers.

Les données recueillies pour le transport intermodal montrent que, sur les trois types de transport intermodal (transport maritime à courte distance/route, navigation intérieure/route, rail/route), le transport maritime à courte distance/route présente les coûts les plus bas par unité de chargement (UCL), tandis que le transport maritime à courte distance/route est le mode de transport le plus coûteux. Le transport intermodal rail/route se situe au milieu. Si l'on considère qu'il existe des différences significatives dans la distance moyenne des différents modes de transport et qu'on les prend en compte en calculant une mesure EUR/tkm, le classement inverse des coûts apparaît. Le transport SSS semble être le mode le moins cher, suivi du rail/route, tandis que le transport IWW/route est le plus cher.

Le transport intermodal est rentable, mais peu d'informations sont disponibles sur les marges bénéficiaires. Les réponses à la consultation des parties prenantes, triangulées avec la littérature, indiquent une fourchette potentielle de 2 à 20 %. Le facteur crucial pour la rentabilité du transport intermodal rail/route est la longueur du tronçon principal par rapport aux tronçons routiers initiaux/finaux. Pour le transport maritime/route à courte distance et le transport fluvial/route, le facteur le plus pertinent pour la rentabilité est plutôt le volume de fret.

Les données recueillies pour le transport intermodal accompagné montrent qu'il est nettement plus coûteux que le transport intermodal non accompagné. Cela est dû aux contraintes techniques des trains accompagnés, qui transportent moins d'unités de chargement et plus de poids que le transport non accompagné (puisque leur poids comprend également l'unité de traction du camion).

L'éventail des distances concurrentielles minimales ou d'équilibre rapportées est large. La plupart des sources indiquent une distance d'équilibre, à partir de laquelle les opérations ferroviaires deviennent rentables ou compétitives par rapport au transport routier, comprise entre 100 et 600 km, mais des distances en dehors de cette fourchette sont également citées. Cela dépend d'un certain nombre de facteurs. Les volumes de fret élevés et la fréquence des navettes, par exemple entre les centres industriels et les ports en eau profonde, peuvent potentiellement rendre rentables même les courtes distances. Les marchandises de grande valeur ou celles qui doivent être transportées par rail, par exemple certaines marchandises chimiques, peuvent être transportées de manière rentable sur de petites distances. En outre, dans le cas du transport intermodal, un transbordement efficace, par exemple des terminaux modernes, et un transport efficace du dernier kilomètre, améliorent la compétitivité du rail, diminuant ainsi la distance concurrentielle minimale. Enfin, la rapidité du service est pertinente. Si l'infrastructure ferroviaire est encombrée et que les horaires ne sont pas respectés, la distance concurrentielle minimale augmente.

L'étude aborde également l'élasticité de la demande par rapport au prix, qui mesure la façon dont la demande varie en fonction des changements de prix du fret ferroviaire. Les estimations de l'élasticité ont été principalement recueillies à partir de la littérature publiée disponible et des rapports de recherche non publics fournis par les institutions et les autorités, soutenues par un petit nombre de réponses dans la consultation des parties prenantes. Ces estimations suggèrent que les élasticités de prix pour les marchandises en vrac ont tendance à être faibles. De même, la demande de trains complets est le plus souvent inélastique. Les preuves suggèrent que, dans de nombreux cas, l'aide d'État pour ces segments pourrait ne pas être bien ciblée. Les élasticités pour les autres catégories de fret, les wagons isolés et le transport intermodal ont tendance à être plus élevées. Cela est probablement dû à la forte concurrence de la route, entre autres facteurs. Lorsque l'on vise un transfert modal, les données indiquent que les aides d'État dans ces segments pourraient s'avérer utiles pour augmenter le volume de transport sur le rail.

Conception des aides d'État au fret ferroviaire

L'étude a également examiné certaines caractéristiques de la conception des aides d'État au fret ferroviaire. Les types d'aides d'État s'adressant aux services de fret ferroviaire structurellement déficitaires ; les seuils d'intensité de l'aide permettant de considérer l'aide d'État comme nécessaire et proportionnelle ; la conception des régimes pour les entreprises en phase de démarrage, la répercussion de l'aide accordée aux entreprises ferroviaires et l'efficacité des aides d'État destinées aux utilisateurs finaux et aux entreprises ferroviaires.

Premièrement, le transport par wagon unique a le potentiel de transférer des volumes de transport de la route vers le rail, en particulier dans les situations où le transport intermodal n'est pas une alternative viable. Malgré ce potentiel, un montant important d'aides d'État est probablement nécessaire pour le rendre compétitif dans la plupart des scénarios. Les chemins de fer autrichiens montrent que les subventions peuvent être efficaces pour maintenir des opérations de wagons uniques importantes. En complément, les gouvernements pourraient tenter d'encourager les investissements dans les infrastructures ou le matériel roulant afin d'améliorer les conditions des EF qui effectuent des transports par wagon unique.

Un autre service qui ne peut exister sans subventions est le transport intermodal accompagné. Des aides d'État sont accordées aux opérateurs de tels services en Autriche, en Roumanie et en Suisse, afin de compenser leur coût plus élevé par rapport à la route. En effet, les transporteurs ne peuvent être attirés par les services de transport accompagné que si des prix plus bas et une durée de transport plus courte leur sont proposés par rapport au transport routier.

Deuxièmement, l'étude a évalué les seuils d'intensité de l'aide pour la présomption de nécessité et de proportionnalité. Les parties prenantes ont indiqué que pour inciter les entreprises ferroviaires à transférer le trafic de la route vers le rail, 30 % des coûts totaux est un seuil trop bas pour garantir la proportionnalité et la nécessité des aides d'État. Un exemple mentionné dans les réponses est que, dans certains pays, les redevances d'accès aux voies représentent à elles seules 30% des coûts totaux du transport ferroviaire de marchandises. Des seuils plus élevés, par exemple entre 50% et 60%

comme l'a suggéré une partie prenante, pourraient inciter les parties prenantes à développer le fret ferroviaire ou les services intermodaux. En outre, les parties prenantes ont indiqué que le seuil du coût total doit être augmenté si le seuil de l'aide à la réduction des coûts externes est augmenté de manière significative. Étant donné que ces deux seuils limitent le montant des aides d'État qui peuvent être accordées en vertu de l'hypothèse de nécessité et de proportionnalité, le fait d'augmenter un seuil sans ajuster le second entraverait l'efficacité globale des aides d'État au fret ferroviaire.

L'étude a également examiné la relation entre le coût supplémentaire du transport ferroviaire par rapport au transport routier d'une part, et la moitié du coût externe supplémentaire du transport ferroviaire par rapport au transport routier (le coût éligible) d'autre part. Pour la majorité des États membres disposant de données, une aide d'État compensant la moitié du différentiel de coût externe (50%) entre les deux modes de transport ne suffirait pas à rendre les services de fret ferroviaire compétitifs par rapport aux services de fret routier. À l'inverse, en République tchèque, en Lituanie, en Pologne et en Espagne, la différence de coûts totaux entre le rail et la route est approximativement égale à la moitié du différentiel de coûts externes entre les deux modes de transport. Les aides d'État couvrant les coûts éligibles pourraient donc combler l'écart de coût entre les deux types de transport dans ces pays.

Troisièmement, plusieurs États membres ont proposé des régimes d'aide d'État pour les jeunes entreprises de services de transport intermodal innovants. L'expérience de ces régimes suggère que le manque de flexibilité en termes de durée du régime, de type de services et d'intensité de l'aide peut faire échouer un régime. Les États membres ont également proposé des régimes d'aides d'État pour réduire le coût d'accès aux infrastructures, par exemple en offrant des réductions du prix d'accès aux voies. Certains de ces régimes ont été introduits en réaction à la pandémie de COVID-19. Une analyse ex post rendue publique était disponible pour deux régimes, elle était positive. Les régimes ont effectivement augmenté le volume de fret ferroviaire.

Quatrièmement, l'étude a examiné les preuves existantes de l'impact des régimes d'aides d'État sur le marché du fret ferroviaire. Les preuves descriptives suggèrent qu'il y a une répercussion partielle des aides d'État dans les cas où l'aide n'est pas versée directement à l'utilisateur final. Les données indiquent également que les augmentations des coûts de transport routier visant à encourager le transfert modal, qui peuvent être considérées comme l'inverse des aides d'État, ne sont répercutées sur les utilisateurs finaux que par les grands transporteurs ayant un pouvoir de négociation. La mise en place d'exigences comptables pour une répercussion totale ou proportionnelle des aides d'État peut être considérée comme un mécanisme imparfait pour faciliter une répercussion au moins partielle des aides. Toutefois, les données relatives au transport de passagers indiquent que les réductions de prix pour les utilisateurs finaux peuvent être compensées par des prix pré-subvention plus élevés par rapport aux services non subventionnés.

Les évaluations ex post des régimes d'aides d'État dans le secteur du fret ferroviaire sont rares, ce qui rend difficile la comparaison de l'efficacité et de l'efficience des régimes destinés aux utilisateurs des services ferroviaires (du côté de la demande) et des régimes destinés aux entreprises ferroviaires (du côté de l'offre). L'évaluation des programmes italiens Ferrobonus et Ecobonus destinés aux utilisateurs finaux a révélé leur effet positif significatif sur le volume de transfert modal. L'évaluation des programmes autrichiens d'aide aux entreprises ferroviaires pour le transport combiné innovant a conclu qu'ils ont permis un transfert modal allant jusqu'à 36% en tkm dans tout le pays. Les preuves contenues dans ces évaluations sont de nature purement descriptive. Aucune preuve comparable de l'efficacité de ces régimes n'est disponible. L'introduction de l'obligation d'évaluer les régimes dans les nouvelles lignes directrices sur les chemins de fer, comme c'est le cas dans d'autres lignes directrices sur les aides d'État, pourrait faciliter la production de preuves et permettre des décisions mieux informées sur la conception des régimes d'aides d'État à l'avenir.

Il existe des arbitrages entre le potentiel des aides d'État à faciliter le transfert modal et le risque de distorsion de la concurrence. On peut s'attendre à ce que les aides d'État à l'exploitation ferroviaire réduisent les coûts d'exploitation à court terme. Par rapport aux aides à l'investissement, les aides d'État à l'exploitation ont un potentiel plus élevé de distorsion de la concurrence dans le segment du fret ferroviaire, mais elles peuvent aussi faciliter un transfert modal vers le rail à court terme. On peut s'attendre à ce que les aides d'État à l'investissement pour l'infrastructure et le matériel roulant réduisent les coûts d'exploitation à long terme en augmentant la capacité et en soutenant l'utilisation de solutions techniques modernes et efficaces. Par rapport aux aides d'État au fonctionnement, ces aides seraient moins susceptibles de fausser la concurrence dans le segment du fret ferroviaire, mais il faudrait plus de temps pour faciliter un transfert modal vers le rail.

Kurzfassung

Die Schiene, die einst den Güterverkehr dominierte, hat ihre beherrschende Stellung an den Straßenverkehr verloren. Obwohl der Schienengüterverkehr in einigen Segmenten nach wie vor wettbewerbsfähig ist, ist sein Anteil am Güterverkehr in Europa in der zweiten Hälfte des 20. Jahrhunderts stetig zurückgegangen. Für diesen Rückgang gibt es verschiedene Gründe, darunter den wirtschaftlichen Strukturwandel weg von der Schwerindustrie, der zu einer Nachfrage nach flexibleren Straßenverkehrslösungen führte, sowie umfangreiche Investitionen in die Straßeninfrastruktur und Innovationen in der Straßenverkehrslogistik. Die Liberalisierung der nationalen Schienengüterverkehrssektoren in Europa in den letzten zwei Jahrzehnten hat diesen Trend nicht umkehren können.

Im Rahmen des Europäischen Green Deals strebt die Europäische Union (EU) eine Verdoppelung des Schienengüterverkehrs bis 2050 an. Die Überarbeitung der aktuellen Leitlinien der Gemeinschaft für staatliche Beihilfen an Eisenbahnunternehmen (Eisenbahnleitlinien, EL) soll dazu beitragen, dieses ehrgeizige Ziel zu erreichen. Die Generaldirektion Wettbewerb der Europäischen Kommission (DG COMP) hat das Konsortium, bestehend aus E.CA Economics, LEAR, Sheppard Mullin und UEA (das Konsortium), unterstützt durch das Institute for Transport Studies der Universität Leeds, mit einer externen Studie zur Unterstützung der Überarbeitung der EL beauftragt. Diese Studie liefert detaillierte Marktinformationen auf der Grundlage von Sekundärforschung und eigener Datenerhebung, einschließlich einer gezielten Konsultation von Interessengruppen, um den Überarbeitungsprozess der EL zu unterstützen. Die Studie befasst sich mit folgenden Themen: i) Überblick über staatliche Beihilfen und andere staatliche Unterstützungsmaßnahmen für den Schienengüterverkehr; ii) Schieneninfrastruktur einschließlich privater Gleisanschlüsse; iii) Modernisierung und Zugang zu rollendem Material; iv) Kosten, Erträge und Rentabilität von Schienengüterverkehr und intermodalem Verkehr sowie Preiselastizität der Nachfrage nach Schienengüterverkehrsleistungen. Schließlich enthält die Studie Schlussfolgerungen zur Ausgestaltung von staatlichen Beihilfen für den Schienengüterverkehr.

Der Schienengüterverkehr ist in den europäischen Ländern sehr unterschiedlich aufgestellt. Im Jahr 2019, dem letzten Jahr vor der Pandemie, reichte der Anteil des Verkehrsträgers Schiene (auf der Basis des gesamten Transportvolumens auf der Straße, der Schiene, in der Binnenschifffahrt und im Kurzstreckenseeverkehr in Tonnen) von durchschnittlich 4,1% in den südeuropäischen Ländern bis zu 14,5% in den osteuropäischen Ländern. Zu den fünf wichtigsten Güterarten, die auf der Schiene transportiert wurden, gehörten Güter in Containern, Metallerze, Koks, Kohle sowie Grundmetalle. Zusammen machten sie rund 67% des gesamten Schienengüterverkehrsaufkommens in der EU aus. Abgesehen von Containergütern werden diese Arten von Gütern in der Regel mit Ganzzügen befördert. Der intermodale Verkehr, bei dem intermodale Ladeeinheiten wie Container und Wechselbehälter verwendet werden, ist ein wachsendes Segment im Schienengüterverkehr. Sein Anteil am gesamten Schienenverkehr variiert von Land zu Land erheblich und reicht von 1,4% in Lettland bis zu 80% in Griechenland. Der Einzelwagenverkehr ist rückläufig und wird in mehreren Mitgliedstaaten sogar nicht mehr angeboten. Die durchschnittliche Entfernung, die eine Tonne Fracht innerhalb eines Landes zurücklegt, lag europaweit zwischen 43 km und 415 km, mit einem Durchschnitt von 241 km. Auch die Struktur des Schienengüterverkehrsmarkts ist sehr unterschiedlich: Der Anteil des ehemaligen Staatsunternehmens reichte 2019 von 0% bis über 90%.

Überblick über staatliche Beihilfen im Schienengüterverkehrssektor

Um die Art der staatlichen Unterstützungsmaßnahmen für intermodalen Verkehr und Schienengüterverkehr besser zu verstehen, wurde eine Datengrundlage mit 156 relevanten Beihilfeentscheidungen der Europäischen Kommission aus der Entscheidungsdatenbank der Europäischen Kommission zusammengestellt und durch weitere Recherchen ergänzt, um staatliche Unterstützungsmaßnahmen in der Schweiz und Unterstützungsleistungen, die keine staatlichen Beihilfen sind, zu ermitteln.

Wir haben 104 staatliche Fördermaßnahmen zur Unterstützung des Schienengüterverkehrs und der Verlagerung des Güterverkehrs von der Straße auf umweltfreundlichere Verkehrsträger (Schiene, Binnenschifffahrt und Seeverkehr) ermittelt. Die Maßnahmen haben im Laufe der Zeit deutlich an Verbreitung gewonnen: Im Jahr 2012 waren 34 Maßnahmen in Kraft, im Jahr 2021 waren es 64, mit einem Gesamtbudget von 338,06 Millionen Euro im Jahr 2012 und 2,29 Milliarden Euro im Jahr 2021.

Auch bei der Art der Maßnahmen und den geförderten Verkehrsträgern gab es eine große Bandbreite: In der gesamten Untersuchung wurden 88 Maßnahmen zur Förderung des Schienengüterverkehrs, 58 Maßnahmen zur Förderung der intermodalen Infrastruktur, 15 Maßnahmen zur Förderung des Seeverkehrs und 31 Maßnahmen zugunsten der Binnenschifffahrt ermittelt. Auch innerhalb der Maßnahmenarten konnten wir eine große Bandbreite feststellen, da eine Vielzahl unterschiedlicher Projekte und Begünstigter unterstützt wird. So haben wir beispielsweise im Schienengüterverkehrssektor überwiegend Maßnahmen beobachtet, die Schienengüterverkehrsbetreibern und Terminaleigentümern offenstehen, aber auch eine kleine Minderheit von Maßnahmen, die anderen Begünstigten offenstehen, wie Forschungseinrichtungen und Herstellern von rollendem Material.

Die Gesamthöhe der von der Europäischen Kommission im Jahr 2019 - dem letzten Jahr vor der Pandemie - genehmigten staatlichen Betriebsbeihilfen pro tkm war für die meisten Mitgliedstaaten unbedeutend. Nennenswerte Ausnahmen sind Österreich (0,71 ct/km) und Italien (0,48 ct/km), wobei Ersteres den Einzelwagenverkehr und den begleiteten intermodalen Verkehr effektiv im Markt hält und Letzteres trotz relativ hoher staatlicher Betriebsbeihilfen Schwierigkeiten hat, den Anteil des Schienengüterverkehrs zu erhöhen. 2019 meldeten die Tschechische Republik, Litauen und Polen keine staatlichen Beihilfen für den Betrieb des Schienengüterverkehrs in diesem Jahr. Dies schließt nicht aus, dass staatliche Beihilfen mit einer Intensität gewährt wurden, die unter dem für die Anmeldung erforderlichen Niveau liegt.

Um zu beurteilen, inwieweit diese Regelungen eine Verlagerung von der Straße auf die Schiene und andere umweltfreundlichere Verkehrsträger wirksam unterstützt haben, wurde die Datenbank mit fiskalischen Informationen über geplante und/oder tatsächliche Ausgaben und Daten zum Anteil der Verkehrsträger abgeglichen. Aus diesen Daten geht hervor, dass der Anteil der von den staatlicherseits vorrangig geförderten Verkehrsträgern beförderten Güter zurückgegangen ist, das tatsächliche Gesamtvolumen des Schienenverkehrs (in Tonnen) zwischen 2012 und 2019 jedoch gestiegen ist.

Die Veränderungen bei den Anteilen der einzelnen Verkehrsträger sind von Mitgliedstaat zu Mitgliedstaat sehr unterschiedlich. Bei zusammengerechneten Anteilen der Schiene, der Binnenschifffahrt (BSF) und des Kurzstreckenseeverkehrs (KSV) von mehr als 45% der beförderten Tonnen, verzeichneten Lettland und Litauen im Zeitraum von 2012 bis 2019 einen Rückgang des Nicht-Straßenanteils von mehr als 10 Prozentpunkten. In Bulgarien, Griechenland, Finnland, Portugal, Irland, Frankreich, Dänemark und der Schweiz wurden für die Kombination von Schiene, BSF und KSV geringfügige Steigerungen des Anteils der einzelnen Verkehrsträger am Güterverkehr zwischen 2012 und 2019 von 1-7 Prozentpunkten in Tonnen festgestellt. Die Anzahl der staatlichen Unterstützungsmaßnahmen für Nicht-Straßenverkehr und die Höhe der gewährten Finanzmittel variieren in Europa: In einigen Ländern mit einem hohen Anteil des Verkehrsträgers Schiene/BSF/KSV (oder relativ starken Veränderungen des Anteils) gibt es keine Maßnahmen, während in anderen Ländern mit einem geringen Anteil des Verkehrsträgers Schiene/BSF/KSV (oder relativ geringen Veränderungen des Anteils) mehrere Maßnahmen vorhanden sind. Aufgrund der komplexen Faktoren, die den Transportsektor beeinflussen, und der geringen Anzahl verfügbarer Daten ist es schwierig, genau festzustellen, welche Faktoren sich auf Veränderungen des Verkehrsanteils auswirken. Die Korrelationen zwischen staatlicher Unterstützung und dem Modalanteil von Bahn/BSF/KSV sowie die Korrelation zwischen den Veränderungen dieser beiden Variablen sind schwach negativ. Das Fehlen einer eindeutigen Korrelation auf aggregierter Ebene bedeutet jedoch nicht, dass spezifische Maßnahmen keine

Auswirkungen haben: Geografisch und zeitlich gezieltere Befragungen deuten auf das Gegenteil hin, wie z.B. die Umkehrung eines Rückgangs des Schienenanteils in Luxemburg, der offenbar auf den Bau eines neuen Terminals zurückzuführen ist.

Eisenbahninfrastruktur

Die europäische Eisenbahninfrastruktur ist ein komplexes System, das nationale Eisenbahnnetze mit verschiedenen Arten von Serviceeinrichtungen und intermodale Terminals sowie private Anschlussgleise umfasst. Jeder Teil ist komplementär zu den anderen. Es sollte daher klar sein, dass ein Engpass auf einer Ebene des Infrastruktursystems zu Störungen auf anderen Ebenen führen und das Ziel der Verkehrsverlagerung behindern kann. Um zu gewährleisten, dass ein intensiverer Schienenverkehr ohne Verzögerungen abgewickelt werden kann, muss die gesamte Eisenbahninfrastruktur nicht nur in der Lage sein, die derzeitige Belastung zu bewältigen, sondern auch einer steigenden Nachfrage gerecht werden.

Die Analyse der öffentlich zugänglichen Daten über die Anzahl der Serviceeinrichtungen für den Schienenverkehr zeigt, dass in einigen Ländern die vorhandenen Einrichtungen möglicherweise nicht einmal ausreichen, um die derzeitige Nachfrage zu befriedigen. Insbesondere die Dichte der Serviceeinrichtungen wurde analysiert: Je weiter verstreut die Einrichtungen sind, desto höher sind die Kosten für den Schienenverkehr, sowohl wegen der längeren Fahrtzeit zu den Einrichtungen als auch wegen des höheren Risikos von Staus. Dennoch kann eine Analyse der Dichte nur einen Teil der Analyse darstellen, da sie die Kapazität der Anlagen nicht berücksichtigt. Diesbezüglich haben die Marktregulierungsbehörden, die auf die Interessengruppenbefragung geantwortet haben, angegeben, dass die Einrichtungen im Allgemeinen eine gute Verfügbarkeit der angebotenen Dienstleistungen gewährleisten.

Aus den vom Konsortium durchgeführten Befragungen ging hervor, dass die relevanten Interessengruppen die Zahl der Serviceeinrichtungen in Europa für unzureichend halten, sowohl was die Anzahl als auch die Kapazität angeht. Der Marktanteil ist zugunsten der vertikal integrierten etablierten Unternehmen verzerrt, was ihnen die Möglichkeit gibt, andere Marktteilnehmer zu benachteiligen. Zwar sollte gemäß der Richtlinie 2012/34 ein diskriminierungsfreier Zugang zu den von diesen Einrichtungen erbrachten Dienstleistungen gewährleistet werden, doch kann die Überwachung dieser Verpflichtung für die nationalen Behörden schwierig sein, da viele Faktoren die tatsächliche Fähigkeit der Eisenbahnunternehmen (EVU), Zugang zu diesen Einrichtungen zu erhalten, beeinflussen (z. B. maximale Kapazität der Einrichtung, Effizienz der angebotenen Leistungen und tatsächlicher Zeitaufwand für den Betrieb).

Das Konsortium hat auch die Angemessenheit der intermodalen Terminals untersucht. Sowohl die Analyse öffentlicher Daten als auch die vorhandene Literatur deuten auf einen Mangel an intermodalen Terminals in ganz Europa hin: In vielen Ländern scheinen intermodale Terminals überlastet zu sein, d.h. sie müssen mehr Fracht bewältigen als optimal wäre, was zu Verspätungen und Zugausfällen führen kann. Einige vom Konsortium befragte Manager intermodaler Terminals betonten zwar, dass die Terminals rentabel arbeiten und dass bei einem Nachfrageüberhang mehr Terminals gebaut würden, doch ist zu beachten, dass die Anzahl (und die Art) der intermodalen Terminals in den einzelnen Regionen sehr unterschiedlich ist. So ist es wahrscheinlich, dass die für die Fallstudien analysierten intermodalen Terminals zwar rentabel und in der Lage und bereit sind, ihre Kapazität zu erhöhen, andere intermodale Terminals in anderen Regionen dies jedoch nicht sind; außerdem könnte es an bestimmten Arten von intermodalen Terminals fehlen (z. B. Straße/Land-Wasserstraße), wie einige Teilnehmer Interessengruppenbefragung betonten.

Schließlich haben die Betreiber intermodaler Terminals sowie die für die Studie befragten Interessengruppen wie die European Rail Freight Association (ERFA), die Alliance of Passenger Rail New Entrants in Europe (ALLRAIL) und die Community of European Railway and Infrastructure Companies (CER) darauf hingewiesen, dass das bestehende Schienennetz in Europa überlastet und nicht für den Betrieb von mehr und längeren Zügen geeignet ist. Diese Sicht wurde auch von einem vom Konsortium befragten Spediteur bestätigt.

Die gesammelten Daten deuten darauf hin, dass beide Aspekte die Kapazität der europäischen Eisenbahninfrastruktur beeinträchtigen: In bestimmten Ländern könnte es an intermodalen Terminals mangeln, was jedoch nicht ausschließt, dass das bestehende Schienennetz überlastet ist. Die Tatsache, dass es in bestimmten Gebieten an Terminals mangelt, ist wahrscheinlich auf die geringe Rendite zurückzuführen, welche dahingehende Investitionen versprechen könnten. Verlustbringende Terminals könnten Unterstützung benötigen, um im Geschäft zu bleiben, wiewohl sie die Auswahl für Spediteure und die Anbindung an das nationale Schienennetz verbessern und so die negativen Externalitäten des Straßengüterverkehrs verringern, möglicherweise eine stärkere Nutzung verschiedener Teile des Netzes ermöglichen und den Verkehr aus überlasteten Gebieten umleiten. Wollte man den intermodalen Verkehr fördern, müsste man die Abwägung zwischen einem dichteren intermodalen Terminalnetz und den Kosten für den Unterhalt dieser Terminals berücksichtigen.

Es sind nicht ausschließlich Infrastrukturbetreiber, die das bestehende Schienennetz besitzen und betreiben. Private Gleisanschlüsse sind Gleise in Privatbesitz, die Verladepunkte (z.B. Industrieanlagen oder Lagerhäuser) mit dem Hauptschienennetz verbinden und es den Unternehmen ermöglichen, den Straßentransport auf der ersten und/oder letzten Meile zu vermeiden. Durch die direkte Beförderung von Gütern zwischen der öffentlichen Eisenbahninfrastruktur und dem eigenen Betriebsgelände können Unternehmen das Risiko logistischer Störungen wie Fahrermangel oder Straßenüberlastungen verringern. Der größte Teil des Schienengüterverkehrs in Europa findet zumindest für einen Teil seiner Strecke auf privaten Gleisanschlüssen statt. In Deutschland sind dies fast 85% des Transportvolumens, in Österreich rund 60% und in der Slowakei 70%. Wollte man die Verlagerung auf die Schiene fördern, könnten Gleisanschlüsse also eine zentrale Rolle spielen. Allerdings scheint die Zahl privater Gleisanschlüsse in ganz Europa generell rückläufig zu sein. So sank die Zahl der Gleisanschlüsse in Deutschland von rund 13.000 im Jahr 1993 auf 1.300 im Jahr 2013, während sie in Österreich von 840 im Jahr 2010 auf 521 im Jahr 2020 zurückging.

Trotz der Vorteile, die private Gleisanschlüsse bieten können, sind Lösungen über den Straßentransport in der Regel kurzfristig billiger (und möglicherweise auch langfristig, es sei denn, es kann ein bestimmter Schwellenwert der beförderten Güter erreicht werden) und werden daher von privaten Unternehmen manchmal immer noch bevorzugt. Im Allgemeinen handelt es sich bei Gleisanschlüssen um eine Investition mit einer langen erwarteten technischen Nutzungsdauer (etwa 30 Jahre laut einer Antwort auf die Interessengruppenbefragung). Die wirtschaftliche Nutzungsdauer kann jedoch kürzer ausfallen, da das Risiko besteht, dass das Anschlussgleis in Zukunft nicht mehr bedient werden wird.

Bei der Überlegung, ob die Entwicklung neuer privater Gleisanschlüsse unterstützt werden soll, sind die Faktoren, die deren betriebswirtschaftlichen Nutzen beeinflussen, von Bedeutung. Direkte Subventionsregelungen (wie sie u.a. in Österreich und Deutschland bereits bestehen), die auf eine direkte Senkung der Baukosten abzielen, sind zwar eine mögliche Lösung, doch sollte auch berücksichtigt werden, wie sich die verschiedenen Faktoren (z.B. die beförderte Fracht und die Länge des Anschlussgleises) auf die Wirtschaftlichkeit des Baus eines Anschlussgleises auswirken. Der Bau neuer Gleisanschlüsse könnte möglicherweise auch durch andere Maßnahmen gefördert werden, die beim Zusammenspiel zwischen Gleisanschluss und Eisenbahninfrastruktur ansetzen: So könnte beispielsweise die Erhöhung der Dichte des Schienennetzes die Länge eines Gleisanschlusses und damit die Baukosten und die Finanzierungslücke verringern. Sowohl direkte Subventionen als auch andere politische Optionen könnten potenziell kombiniert werden, wenn es darum geht, den Bau neuer Gleisanschlüsse zu fördern.

Rollendes Material

Aus dem *Fitness Check* der Eisenbahnleitlinien, der im Zeitraum 2019/2020 durch die Europäische Kommission durchgeführt wurde, ergab sich die Besorgnis, dass das rollende Material, also die Lokomotiven und Waggons, in der EU veraltet sein könnte.

Aus der Literatur geht hervor, dass im Jahr 2019 mehr als 50% des Güterwagenbestands in Europa älter als 30 Jahre waren, wobei dieselbe Quelle die durchschnittliche wirtschaftliche Nutzungsdauer auf 35 bis 50 Jahre schätzt. Eine Analyse der nationalen Fahrzeugregister zeigt, dass sich die Situation in den letzten drei Jahren nicht verbessert zu haben scheint: Schienenfahrzeuge für den Personenverkehr sind im Durchschnitt sogar älter als Fahrzeuge für den Güterverkehr, während Triebfahrzeuge im Durchschnitt jünger sind. Eine Ausnahme bilden die Rangier- und sonstigen Lokomotiven (z. B. Dampflokomotiven), die im Durchschnitt fast 40 Jahre alt sind. Ein Faktor, der das Ziel der EU-Strategie für nachhaltige und intelligente Mobilität, den Schienengüterverkehr bis 2050 zu verdoppeln, vereiteln könnte, ist die Tatsache, dass der Sektor bei der derzeitigen Erneuerungsrate auf eine Nettoverkleinerung der Flotte zusteuert. Dies ist darauf zurückzuführen, dass sich ein großer Teil der Fahrzeugflotte dem Ende ihrer Nutzungsdauer nähert und es scheint unwahrscheinlich, dass es derzeit genügend freie Kapazitäten gibt, um die gewünschte Flottenvergrößerung zu erreichen. Dies kann zwar teilweise durch die Nachrüstung alter Fahrzeuge gemildert werden, aber das allein wird wahrscheinlich nicht ausreichen, um den Rückgang der Flottengröße umzukehren.

Das Konsortium untersuchte die Ursachen dieser Situation und insbesondere die Gründe, welche die Eisenbahnunternehmen daran hindern, in die Nachrüstung oder den Ersatz von rollendem Material zu investieren. Im Ergebnis zeigt sich, dass die Hindernisse hauptsächlich finanzieller Art sind und dass insbesondere kleine Betreiber keinen Zugang zu Krediten zu wettbewerbsfähigen Bedingungen haben. Dies könnte auch dazu führen, dass kleinere Unternehmen rollendes Material einsetzt, das wirtschaftlich veraltet ist, d.h. Fahrzeuge mit höheren Betriebskosten, und deren Ersatz oder Nachrüstung rentabler wäre. Diese finanziellen Restriktionen können auch zu einem Wettbewerbsvorteil für staatliche Eisenbahnunternehmen führen, die aufgrund impliziter oder expliziter staatlicher Bürgschaften zu besseren Bedingungen Zugang zu Krediten erhalten können. Während der Umfang der privaten Finanzierung seit 2011 stetig gestiegen ist, ist eine gewisse Heterogenität zwischen den Marktsegmenten zu beobachten, wobei die liberalisierten Segmente eine höhere Konzentration privater Finanzierung aufweisen. Angesichts des Zustands der rollenden Materials in Europa und seiner suboptimalen Erneuerungsrate könnte öffentliche Finanzierung erforderlich sein, um die Flottenmodernisierung zu gewährleisten.

Die beobachtete Erneuerungsrate und der Zustand des vorhandenen rollenden Materials könnten tatsächlich die erheblichen Kosten und die Komplexität widerspiegeln, die mit dem Zugang zum rollenden Material verbunden sind. Der Zugang zu rollenden Material für den Personenverkehr und zu Triebfahrzeugen scheint besonders komplex zu sein und stellt ein großes Hindernis für den Markteintritt und/oder die Expansion in den entsprechenden Segmenten dar. Die Hauptursache für diese Komplexität ist die fehlende technische Standardisierung des rollenden Materials in Europa, die sich aus den Unterschieden in der Eisenbahninfrastruktur der einzelnen Mitgliedstaaten und aus redundanten nationalen technischen und betrieblichen Vorschriften ergibt, die trotz eines verbindlichen europäischen Rahmens für technische Spezifikationen für die Interoperabilität (TSI) noch immer fortbestehen. Dies stellt ein technisches Hindernis dar, das dem Austausch von rollendem Material zwischen verschiedenen Ländern entgegensteht und somit die Entwicklung eines europaweiten und gut funktionierenden Marktes für einen solchen Austausch erschwert. Für Güterwagen scheint dies kein Problem zu sein, da sie praktisch auf dem gesamten europäischen Schienennetz verkehren können; Güterwagen müssen nicht an die Oberleitung angeschlossen werden und benötigen keine besonderen technischen Merkmale, um auf verschiedenen nationalen Eisenbahnnetzen verkehren zu können. Die einzige Einschränkung für ihre Interoperabilität ist die unterschiedliche Spurweite in bestimmten Ländern (z. B. Spanien und Portugal), obwohl moderne Güterwagen über eine variable Spurweite verfügen, die dieses potenzielle Problem löst.

Dieser Mangel an Standardisierung wirkt sich auch auf den Gebrauchtmarkt für rollendes Material aus, der ebenfalls meist auf eine nationale Dimension beschränkt ist. Infolgedessen besteht die Besorgnis, dass die etablierten Eisenbahnunternehmen dazu beitragen könnten, den Zugang zu Fahrzeugen für andere Marktteilnehmer teurer zu machen. Neue Eisenbahnunternehmen können oft keine gebrauchten Fahrzeuge aus anderen Mitgliedstaaten beziehen, und die etablierten Unternehmen sind in jedem Land die Hauptlieferanten von gebrauchtem Material, da sie vor der Liberalisierung der Eisenbahnmärkte die einzigen Käufer von Schienenfahrzeugen waren.

Die vom Konsortium durchgeführten Analysen deuten darauf hin, dass für die etablierten Unternehmen ein Anreiz bestehen könnte, noch nutzbares rollendes Material zu verschrotten oder einzulagern, anstatt es auf dem Markt zu verkaufen oder zu verleasen. Dies gilt insbesondere für den Personenverkehrssektor. Ein solches Verhalten hätte dann erhebliche Auswirkungen auf den tatsächlichen oder potenziellen Wettbewerb, wenn der Zugang zu gebrauchtem Material nicht wirksam durch andere Quellen ersetzt werden könnte, insbesondere durch die Möglichkeit des Kaufs neuer Fahrzeuge oder des Leasings von Fahrzeugen. Die Förderung der technischen Normung und damit der Interoperabilität von rollendem Material in der EU scheint von größter Bedeutung zu sein, um den Zugang zu rollendem Material für neue Marktteilnehmer zu verbessern und letztlich auch die Kosten zu senken. Dies steht bereits eindeutig auf der Agenda der Kommission: Das Europäische Eisenbahnverkehrsleitsystem (ERTMS) umfasst Normen für das Management und die Interoperabilität der Signalgebung für Eisenbahnen durch die Europäische Union, was derzeit eines der Haupthindernisse für die Interoperabilität darstellt, und die Entwicklung einer neuen TSI, die noch im Jahr 2022 erwartet wird und technische Normen schaffen soll, welche den Betrieb von Reisezugwagen auf einem großen Teil des Normalspurnetzes der Union ermöglichen.

Nicht nur die Rate, mit der Fahrzeuge ersetzt werden, scheint suboptimal zu sein, sondern auch die Geschwindigkeit, mit der sie auf innovative und saubere Technologien nachgerüstet werden, erscheint zu langsam. Daher könnten öffentliche Mittel auch benötigt werden, um die Einführung solcher Technologien zu fördern. Ein weiterer Vorteil dieser Technologien besteht darin, dass sie die CO_2-Emissionen und andere Schadstoffe sowie den Eisenbahnlärm sowohl direkt als auch indirekt durch eine höhere Effizienz des Schienenverkehrs verringern können. So wirkt sich beispielsweise die Umstellung auf saubere Antriebssysteme direkt auf die Verringerung der Emissionen aus, während die Einführung neuer technologischer Lösungen zu einer Steigerung der Produktivität des rollenden Materials führen kann, was die Betriebskosten senkt, die Verlagerung des Verkehrs auf die Schiene fördert und letztlich zu geringeren Emissionen führt.

Trotz der langfristigen Effizienzvorteile wird in der Literatur berichtet, dass die Kosten und Risiken, welche derzeit mit der Einführung neuer und sauberer Technologien verbunden sind, die Unternehmen dazu veranlassen könnten, die Umstellung auf diese Technologien so lange hinauszuzögern, bis ihr rollendes Material das Ende seiner Lebensdauer erreicht hat und ohnehin ersetzt werden sollte. Einer der Gründe dafür ist, dass die Ausrüstung mit diesen Technologien nur dann Vorteile bringt, wenn sie in größerem Umfang eingeführt werden, was für die Unternehmen einen Anreiz darstellt, die Umstellung zu verzögern. Darüber hinaus weichen die Anreize von Eisenbahnunternehmen und Infrastrukturbetreibern oft voneinander ab; für letztere erfordert die Umstellung auf bestimmte Technologien hohe Investitionen, aber wenig bis gar keine Vorteile. Aus politischer Sicht könnte es zur Förderung der Einführung dieser Technologien zielführend sein, für eine EU-weite Koordinierung zu sorgen, z.B. indem sie durch eine Aktualisierung der einschlägigen technischen Spezifikationen für die Interoperabilität verbindlich vorgeschrieben werden, natürlich mit einer angemessenen Übergangsfrist. Auch Subventionen für Vorreiter wären denkbar, wenn man Anreize für die Umstellung schaffen wollte.

Ganz allgemein könnten Subventionen zur Förderung der Erneuerung von rollendem Material angesichts des Zustands der bestehenden Fahrzeugflotte einem doppelten Ziel dienen: Einerseits könnten sie die Produktionsrate erhöhen und sicherstellen, dass die Fahrzeugflotte in den nächsten Jahren nicht schrumpft; andererseits könnten sie die Einführung neuer Technologien fördern, da es Hinweise darauf gibt, dass Eisenbahnunternehmen angesichts der hohen Kosten für die Nachrüstung dazu neigen, mit der Einführung dieser Technologien zu warten, bis das rollende Material ersetzt werden muss. Es ist jedoch zu bedenken, dass das Eisenbahnsystem miteinander verbunden ist, so dass auch andere Formen staatlicher Beihilfen (z.B. Betriebszuschüsse oder Investitionsbeihilfen für die Eisenbahninfrastruktur) die Branche rentabler machen und Anreize für Investitionen in die Beschaffung von rollendem Material schaffen können.

Kosten, Einnahmen und Rentabilität von Schienengüterverkehr

Die Studie enthält Schätzungen der Kosten, Einnahmen und der Rentabilität von Schienenverkehrsleistungen auf der Basis der Interessengruppenbefragung, der wissenschaftlichen Literatur, von Unternehmensabschlüssen sowie von Branchenberichten und Datenbanken. Die Maßeinheit sind Eurocent pro Nettotonnenkilometer (Cent/tkm), was die tatsächliche Transportleistung in Bezug auf Gewicht und Entfernung widerspiegelt. Soweit keine detaillierten Daten verfügbar sind, verfolgen wir einen Top-Down-Ansatz und verwenden aggregierte Daten, z. B. Kosten oder Erträge für alle Schienengüterverkehrsdienste eines Eisenbahnunternehmens auf Jahresebene, und leiten ein Kennzahl pro tkm ab, indem wir die Gesamtkosten oder -erträge durch das Frachtvolumen dividieren.

Wir stellen die Rentabilität des Schienengüterverkehrs aufgeschlüsselt nach mehreren Dimensionen dar. Erstens unterscheiden sich Kosten, Erträge und die daraus resultierende Marge im Schienengüterverkehr **je nach Land**, was unter anderem auf geografische Unterschiede, die verfügbare Infrastruktur, unterschiedliche Arbeitskosten, Steuern und Vorschriften sowie Unterschiede im Produktmix zurückzuführen ist. Aus den gemeldeten Rentabilitätszahlen geht hervor, dass der Schienengüterverkehrssektor in Italien, den Niederlanden und Polen im Durchschnitt rentabel ist; in der Tschechischen Republik, Litauen und Spanien liegt seine Marge knapp an oder über einer schwarzen Null; in Österreich, Deutschland, Rumänien, der Slowakei, Schweden und der Schweiz ist er verlustbringend. Die durchschnittliche Rentabilität des Sektors in einem Land bedeutet jedoch nicht, dass alle Schienengüterverkehrsleistungen verlustbringend sind: EVU, die in diesen Ländern spezifische Leistungen anbieten, können immer noch profitabel arbeiten.

Die zweite Dimension ist die **Zugart**, die für die Zwecke dieser Studie in drei Kategorien unterteilt wird: Ganzzüge, Einzelwagenverkehr und intermodaler Verkehr. Auch wenn die Abgrenzung zwischen diesen Kategorien immer unschärfer wird (z. B. Einsatz intermodaler Ladeeinheiten im Einzelwagenverkehr), sind diese drei Kategorien in der Branche noch weit verbreitet. Die Kosten für Ganzzüge sind aufgrund von Skaleneffekten und einer einfachen Organisation relativ niedrig. Die Konkurrenz durch den Straßenverkehr ist begrenzt, aber es gibt einen Wettbewerbsdruck innerhalb des Schienengüterverkehrs und in einigen Fällen durch die Schifffahrt. Daher weisen Ganzzüge in der Regel eine kleine, aber positive Gewinnmarge auf. Der Einzelwagenverkehr ist insgesamt unrentabel: Hohe Netz- und Investitionskosten gepaart mit geringer Auslastung, längeren Transportzeiten und unbefriedigender Zuverlässigkeit machen ihn gegenüber der Straße und dem intermodalen Verkehr meist nicht wettbewerbsfähig. Der Betrieb von Einzelwagenladungen in bestimmten Gütersegmenten (z.B. Chemie) oder unter bestimmten Bedingungen (leistungsstarke Infrastruktur, modernes rollendes Material) kann jedoch rentabel sein. Der Markt für den intermodalen Verkehr wächst und bleibt trotz des starken Wettbewerbs sowohl innerhalb des Segments als auch durch den Straßenverkehr rentabel.

Die dritte Dimension ist die Art des Eisenbahnunternehmens: Die Kosten der **etablierten nationalen Eisenbahnunternehmen** sind in der Regel höher als die der **neuen Marktteilnehmer**, was auf die unterschiedliche betriebliche Effizienz, den unterschiedlichen Zusammensetzung der transportierten Güter und der Art der angebotenen Dienstleistungen zurückzuführen ist. Dies führt in der Regel zu einer geringeren Rentabilität für die etablierten Unternehmen im Vergleich zu den neuen Marktteilnehmern.

Die vierte Dimension sind die **Frachtkategorien**. Es liegen nur wenige Daten über die spezifischen Kosten für bestimmte Güterkategorien vor. Soweit es Unterschiede bei den Kosten gibt, sind diese häufig auf die Zugart zurückzuführen. Auf der Einnahmenseite stechen Automobilprodukte mit den höchsten Einnahmen pro Tonnenkilometer (tkm) hervor, gefolgt von Grundmetallen, Chemikalien und Koks.

Die fünfte Dimension ist der Vergleich zwischen **nationalen und internationalen** Strecken: Im Durchschnitt fallen auf nationalen Strecken höhere Kosten (pro tkm) an, während die Einnahmen ähnlich bleiben, so dass der internationale Schienengüterverkehr rentabler ist als der nationale. Dies ist wahrscheinlich auf die längere Transportdistanz auf internationalen Strecken zurückzuführen, welche die Durchschnittskosten trotz der zusätzlichen Kosten durch den Grenzübertritt senken.

Der Schienengüterverkehr profitiert von Skaleneffekten aufgrund niedriger variabler Kosten und hoher Fixkosten. Folglich wird die Schiene gegenüber der Straße umso wettbewerbsfähiger, je größer die **Transportentfernung** und die **Zuglänge** (oder das Frachtvolumen) sind. Je größer der Anteil der Fixkosten ist, desto stärker sinken die Durchschnittskosten mit zunehmender Entfernung oder Zuglänge. Wir führen eine Simulation durch, die zeigt, dass die durchschnittlichen Kosten pro tkm i) um etwa 12% sinken, wenn die durchschnittliche Transportentfernung (von 354 km) um zusätzliche 100 km erhöht wird; ii) um etwa 2% sinken, wenn ein Zug mit typischerweise 28 Wagen um einen weiteren Wagen erweitert wird.

Die Wettbewerbsfähigkeit des Schienenverkehrs auf längeren Strecken kann durch Ineffizienzen an den **nationalen Grenzen** beeinträchtigt werden. Der grenzüberschreitende Verkehr ist durch zusätzliche Kosten gekennzeichnet, welche durch fehlende technische Interoperabilität, zusätzliche Arbeitskosten und nicht harmonisierte Vorschriften und Normen entstehen. Das Ausmaß des Kostenanstiegs hängt von den technischen Lösungen ab, die zur Bewältigung von Interoperabilitätsproblemen und zusätzlichen Arbeitskosten aufgrund des Grenzübertritts gewählt werden. An einigen Grenzen ist der Kostenanstieg vernachlässigbar, da sich die Spurweite, der Bahnstrom und die Sprache nicht ändern. An anderen Grenzen sind die Kosten des Grenzübertritts, umgerechnet in Cent pro tkm, jedoch erheblich: 5% im Vergleich zu einem ansonsten identischen Inlandstransport derselben Entfernung an einer mittelschweren Grenze wie Spanien-Portugal mit unterschiedlichem Bahnstrom und unterschiedlicher Sprache; rund 20% für Litauen-Polen; und zwischen 38% und 73% für die Grenze Spanien-Frankreich, wo der Grenzübertritt neben Bahnstrom- und Sprachunterschieden auch eine Änderung der Spurweite beinhaltet. Zu diesen Faktoren kommt die zusätzliche Komplexität der Zusammenarbeit mit mehreren Infrastrukturbetreibern, Fahrzeuganbietern und Regulierungssystemen hinzu, die Eisenbahnunternehmen davon abhalten können, grenzüberschreitende Leistungen anzubieten.

Die für den **intermodalen Verkehr** erhobenen Daten zeigen, dass von den drei Arten des intermodalen Verkehrs (Kurzstreckenseeverkehr/Straße, Binnenschifffahrt/Straße, Schiene/Straße) BSF/Straße die niedrigsten Kosten pro Ladeeinheit (LE) aufweist, während KSV/Straße die teuerste Verkehrsart ist. Der intermodale Verkehr Schiene/Straße liegt in der Mitte. Wenn man bedenkt, dass es erhebliche Unterschiede bei den durchschnittlichen Entfernungen der verschiedenen Verkehrsträger gibt, und diese durch die Berechnung eines EUR/tkm-Maßes berücksichtigt, ergibt sich eine umgekehrte Kostenreihenfolge: Der KSV/Straße scheint die günstigste Variante zu sein, gefolgt von Schiene/Straße, während BSF/Straße am teuersten ist.

Der intermodale Verkehr ist rentabel, aber es liegen nur wenige Informationen über die Gewinnspannen vor. Die Antworten auf die Interessengruppenbefragung, welche mit der Literatur abgeglichen wurden, deuten auf eine mögliche Spanne von 2-20% hin. Der entscheidende Faktor für die Rentabilität im intermodalen Verkehr Schiene/Straße ist die Länge des Hauptlaufs auf der Schiene im Vergleich zum Vor- und Nachlauf auf der Straße. Im Kurzstreckenseeverkehr/Straße und in der Binnenschifffahrt/Straße ist der wichtigste Faktor für die Rentabilität hingegen das Frachtvolumen.

Die für den **begleiteten intermodalen Verkehr** erhobenen Daten zeigen, dass dieser deutlich teurer ist als der unbegleitete intermodale Verkehr. Dies ist auf die technischen Restriktionen der begleiteten Züge zurückzuführen, die weniger Ladeeinheiten und mehr Gewicht befördern als der unbegleitete Verkehr (da ihr Gewicht auch die Sattelzugmaschine des Lkw umfasst).

Die Spannweite der recherchierten **Mindestentfernungen für Profitabilität oder Wettbewerbsfähigkeit** ist groß: Die meisten Quellen gehen von einer Mindestentfernung zwischen 100 und 600 km aus, aber es werden auch Entfernungen außerhalb dieses Bereichs genannt. Die Mindestentfernung, ab der Schienengüterverkehr rentabel wird, hängt von einer Reihe von Faktoren ab. Ein hohes Frachtaufkommen und eine hohe Pendeltaktung, z.B. zwischen Industriezentren und Häfen, können selbst kurze Entfernungen rentabel machen. Hochwertige Güter oder Güter, die auf der Schiene transportiert werden müssen, z.B. bestimmte chemische Güter, können auch über geringe Entfernungen rentabel transportiert werden. Im Falle des intermodalen Verkehrs verbessern außerdem ein effizienter Güterumschlag, z.B. moderne Terminals, und ein effizienter Transport auf der letzten Meile die Wettbewerbsfähigkeit der Schiene, wodurch die Mindestentfernung sinkt. Schließlich kann sich auch die Pünktlichkeit des Dienstes auf die relevante Mindestentfernung auswirken: Wenn die Eisenbahninfrastruktur überlastet ist und die Fahrpläne nicht eingehalten werden, erhöht sich die Mindestentfernung, ab der die Schiene wettbewerbsfähig wird.

Die Studie befasst sich auch mit der **Preiselastizität der Nachfrage**, die misst, wie sich die Nachfrage bei Änderungen der Preise für den Schienengüterverkehr verändert. Die Daten zu Elastizitäten wurden hauptsächlich aus der verfügbaren veröffentlichten Literatur und nicht-öffentlichen Forschungsberichten von Institutionen und Behörden zusammengetragen und durch eine kleine Anzahl von Antworten im Rahmen der Interessengruppenbefragung ergänzt. Diese Daten deuten darauf hin, dass die Preiselastizitäten für Massengüter eher gering sind. Auch die Nachfrage nach Ganzzügen ist meist unelastisch. Die Ergebnisse deuten weiterhin darauf hin, dass staatliche Beihilfen für diese Segmente in vielen Fällen nicht zielgerichtet sind. Die Elastizitäten für andere Güterkategorien, den Einzelwagenverkehr und den intermodalen Verkehr sind tendenziell höher. Dies ist wahrscheinlich u.a. auf den starken Wettbewerb mit der Straße zurückzuführen. Wenn eine Verlagerung auf andere Verkehrsträger angestrebt wird, könnten sich staatliche Beihilfen in diesen Segmenten als hilfreich erweisen, um das Transportvolumen auf der Schiene zu erhöhen.

Gestaltung von staatlichen Beihilfen für den Schienengüterverkehr

Die Studie untersuchte auch ausgewählte Merkmale der Gestaltung staatlicher Beihilfen im Schienengüterverkehr: Arten staatlicher Beihilfen für strukturell defizitäre Schienengüterverkehrsleistungen; Schwellenwerte für die Beihilfeintensität, um staatliche Beihilfen als notwendig und verhältnismäßig zu erachten; Gestaltung von Regelungen für Unternehmensneugründungen; Weitergabe von Beihilfen an Eisenbahnunternehmen und die Effizienz staatlicher Beihilfen für Endnutzer und Eisenbahnunternehmen.

Erstens hat der Einzelwagenverkehr das Potenzial, Transportvolumen von der Straße auf die Schiene zu verlagern, insbesondere in Situationen, in denen der intermodale Verkehr keine praktikable Alternative darstellt. Ungeachtet dieses Potenzials ist in den meisten Szenarien wahrscheinlich ein erheblicher Betrag an staatlichen Beihilfen erforderlich, um ihn wettbewerbsfähig zu machen. Der österreichische Schienenverkehr ist ein Beispiel dafür, dass Subventionen zur Aufrechterhaltung eines umfangreichen Einzelwagenverkehrs wirksam sein können. Ergänzend könnten die Regierungen versuchen, Investitionen in die Infrastruktur oder das rollende Material zu fördern, um die Bedingungen für EVU zu verbessern, die Einzelwagenverkehr durchführen.

Ein weiterer Dienst, der ohne Subventionen nicht existieren kann, ist der begleitete intermodale Verkehr. In Österreich, Rumänien und der Schweiz werden den Betreibern solcher Dienste staatliche Beihilfen gewährt, um die im Vergleich zum Straßenverkehr höheren Kosten auszugleichen. Spediteure können nur dann für den begleiteten Verkehr gewonnen werden, wenn ihnen im Vergleich zum Straßenverkehr niedrigere Preise und kürzere Beförderungszeiten geboten werden.

Zweitens wurden in der Studie die Schwellenwerte für die Beihilfeintensität im Hinblick auf die Vermutung der Notwendigkeit und Verhältnismäßigkeit bewertet. Die befragten Interessensgruppen wiesen darauf hin, dass 30% der Gesamtkosten eine zu niedrige Schwelle sind, um Anreize für die Verlagerung des Verkehrs von der Straße auf die

Schiene zu schaffen und die Verhältnismäßigkeit und Notwendigkeit staatlicher Beihilfen zu gewährleisten. Ein in den Antworten genanntes Beispiel ist, dass in einigen Ländern die Trassenpreise allein 30% der Gesamtkosten des Schienengüterverkehrs ausmachen. Höhere Schwellenwerte, z.B. zwischen 50 und 60%, wie von einem Beteiligten vorgeschlagen, könnten Anreize für die Entwicklung des Schienengüterverkehrs oder intermodaler Dienste bieten. Darüber hinaus wiesen die Beteiligten darauf hin, dass der Schwellenwert für die Gesamtkosten angehoben werden muss, wenn der Schwellenwert für Beihilfen zur Verringerung der externen Kosten deutlich erhöht wird. Da beide Schwellenwerte die Höhe der staatlichen Beihilfen begrenzen, die unter der Annahme der Notwendigkeit und Verhältnismäßigkeit gewährt werden können, würde die Anhebung eines Schwellenwerts ohne Anpassung des zweiten Schwellenwerts die Gesamtwirksamkeit der staatlichen Beihilfen für den Schienengüterverkehr beeinträchtigen.

In der Studie wurde auch das Verhältnis zwischen den Mehrkosten des Schienenverkehrs im Vergleich zum Straßenverkehr einerseits und der Hälfte der zusätzlichen externen Kosten des Straßenverkehrs im Vergleich zum Schienenverkehr (den beihilfefähigen Kosten) andererseits untersucht. In den meisten Mitgliedstaaten, für die Daten vorliegen, würden staatliche Beihilfen, die die Hälfte der Differenz der externen Kosten (50%) zwischen den beiden Verkehrsträgern ausgleichen, nicht ausreichen, um den Schienengüterverkehr gegenüber dem Straßengüterverkehr wettbewerbsfähig zu machen. In der Tschechischen Republik, Litauen, Polen und Spanien hingegen entspricht die Differenz der Gesamtkosten zwischen Schiene und Straße ungefähr der Hälfte der Differenz der externen Kosten zwischen den beiden Verkehrsträgern. Staatliche Beihilfen zur Deckung der beihilfefähigen Kosten könnten daher in diesen Ländern die Kostenlücke zwischen den beiden Verkehrsträgern schließen.

Drittens haben mehrere Mitgliedstaaten staatliche Beihilferegelungen für neu gegründete innovative intermodale Verkehrsanbieter angeboten. Die Erfahrungen mit diesen Regelungen zeigen, dass mangelnde Flexibilität in Bezug auf die Laufzeit der Regelung, die Art der Dienstleistungen und die Beihilfeintensität zum Scheitern der Maßnahmen führen kann. Die Mitgliedstaaten haben auch staatliche Beihilfemaßnahmenangeboten, um die Kosten für den Zugang zur Infrastruktur zu senken, zum Beispiel durch Preisnachlässe für den Streckennutzungsgebühren. Einige dieser Maßnahmen wurden als Reaktion auf die COVID-19-Pandemie eingeführt. Für zwei Maßnahmen lagen öffentlich zugängliche Ex-post-Analysen vor, die positiv ausfielen: Die Maßnahmen haben das Schienengüterverkehrsaufkommen erhöht.

Viertens wurden im Rahmen der Studie die vorhandenen Belege für die Auswirkungen staatlicher Beihilferegelungen auf den Markt für Schienengüterverkehr überprüft. Deskriptive Evidenz deutet darauf hin, dass staatliche Beihilfen in den Fällen, in welchen sie nicht direkt an den Endnutzer gezahlt werden, teilweise weitergegeben werden. Es gibt auch Anhaltspunkte dafür, dass Erhöhungen der Kosten für den Straßengüterverkehr zum Zwecke der Förderung der Verkehrsverlagerung, gewissermaßen das Gegenteil einer staatlichen Unterstützung, nur von größeren Transportunternehmen mit Verhandlungsmacht an die Endnutzer weitergegeben werden. Die Einführung von Rechnungslegungsvorschriften für die vollständige oder anteilige Weitergabe staatlicher Beihilfen kann als unvollkommener Mechanismus zur Erleichterung einer zumindest teilweisen Weitergabe der Unterstützung angesehen werden. Die Erfahrungen im Personenverkehr zeigen jedoch, dass Preissenkungen für die Endnutzer durch höhere Preise vor der Subventionierung im Vergleich zu nicht subventionierten Diensten kompensiert werden können.

Ex-post-Evaluationen staatlicher Beihilfemaßnahmen im Schienengüterverkehr sind selten, was einen Vergleich der Wirksamkeit und Effizienz von Maßnahmen, die sich an die Nutzer von Schienenverkehrsdiensten (Nachfrageseite) richten, mit Regelungen, welche sich an Eisenbahnunternehmen (Angebotsseite) richten, erschwert. Die Bewertung der an Endnutzer gerichteten italienischen Regelungen *Ferrobonus* und *Ecobonus*, ergab, dass sie sich deutlich positiv auf den Umfang der Verkehrsverlagerung auswirken. Die Evaluation der österreichischen Maßnahme für Eisenbahnunternehmen *Innovationsförderprogramm Kombinierter Güterverkehr* ergab, dass sie eine

Verkehrsverlagerung von bis zu 36% in tkm landesweit bewirkte. Die Evidenz in diesen Evaluationen sind rein deskriptiver Natur. Es liegen keine vergleichbaren Nachweise für die Effizienz dieser Maßnahmen vor. Eine Verpflichtung zur Evaluierung von Maßnahmen in den neuen Eisenbahnleitlinien, wie sie auch in anderen Leitlinien für staatliche Beihilfen besteht, könnte es erleichtern, Evidenz für fundiertere Entscheidungen über die künftige Gestaltung von Beihilfemaßnahmen zu gewinnen.

Zwischen dem Potenzial staatlicher Beihilfen, die Verkehrsverlagerung zu unterstützen, und dem Risiko einer Wettbewerbsverzerrung besteht ein Zielkonflikt. Staatliche Betriebsbeihilfen für den Schienengüterverkehr dürften kurzfristig zu einer Senkung der Betriebskosten führen. Im Vergleich zu Investitionsbeihilfen haben staatliche Betriebsbeihilfen ein höheres Potenzial, den Wettbewerb im Schienengüterverkehrssegment zu verzerren, können aber auch kurzfristig eine Verkehrsverlagerung auf die Schiene unterstützen. Staatliche Investitionsbeihilfen für Infrastruktur und Fahrzeuge dürften die Betriebskosten langfristig senken, da sie die Kapazität erhöhen und den Einsatz moderner und effizienter technischer Lösungen fördern. Im Vergleich zu staatlichen Betriebsbeihilfen ist es weniger wahrscheinlich, dass solche Beihilfen den Wettbewerb im Schienengüterverkehr verzerren, aber es würde länger dauern, bis eine Verlagerung auf die Schiene erfolgt.

1. Introduction

1.1 Background

Once at the frontier of transport logistics, rail lost its supremacy to more flexible road solutions. Although rail transport remains competitive in some segments, it experienced a steady decline of its modal share in the second half of the 20th century (European Commission, 2008). More specifically, rail freight's modal share decreased from around 60% in the 1950s to just 18% in 2019.[1] The various reasons for that trajectory included large-scale investments into road infrastructure and a structural shift away from heavy industries towards intermediate and consumer goods, which in turn induced demand for more flexible transport solutions (see e.g. ECM Ventures 2022). The fall in rail freight's modal share has prompted higher average costs. These are attributable to high fixed costs and loss of competitiveness.[2]Entry and expansion in the rail freight sector appear to be a major challenge and operators in market segments struggle to achieve profitability.[3]

Railways have unique advantages over road freight transport, including safety and low pollution. The European Commission (2008) emphasises the need for European rail transport to keep developing and prioritising investment in European rail infrastructure in order to improve its competitiveness.[4] Growth in rail transport will help Member States (MS) to cut greenhouse gas (GHG) emissions,[5] together with local air pollution, road casualties, and reduce their dependency on oil. Against this backdrop, the Union has progressively opened up the rail transport markets, starting in 2001 with the approval of an initial liberalisation package, which was followed by the RG in 2008 (Commission, 2008/C 184/07). More recently, the European Green Deal has promoted shifting freight transport from road to rail or other sustainable modes across Europe, aiming at doubling its volume by 2050.[6]

Despite the policy efforts, the modal share of rail freight transport has not effectively increased. Indeed, based on Eurostat data, the inland modal share of rail stagnated at around 18% between 2005 and 2019, even slightly declining from 2017 onwards.[7] Meanwhile, road transport keeps playing a dominant role in inland freight transport, with approximately a 75.6% share of transported volume in tonnes across MS in 2019. Rail is competitive against road mainly when transporting large quantities of heavy bulk goods such as steel and coal over long distances. However, the volume of these types of freight, associated with traditional heavy industries, has decreased over time as their dominance in Europe has given way to the rise of modern high-tech industries and the service sector.

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[1] Jose Vassallo and Mark Fagan, *Nature or nurture: Why do railroads carry greater freight share in the United States than in Europe?*, Taubman Center research working paper series, number WP05-15, December 20, 2005; European Commission, Eurostat Freight transport statistics – modal split; Deutsches Institut für Wirtschaftsforschung (DIW), Verkehr in Zahlen, Hamburg: Bundesministerium für Verkehr (Federal Ministry of Transport), 2000 and 2020.

[2] See "Bold moves to boost European rail freight": https://www.mckinsey.com/industries/travel-logistics-and-infrastructure/our-insights/bold-moves-to-boost-european-rail-freight.

[3] See "State aid: Commission invites comments on proposed revision of Guidelines on State aid for railway companies": https://ec.europa.eu/commission/presscorner/detail/en/ip_21_7049; See also "Special Report Rail freight transport in the EU: still not on the right track", p. 54: https://www.eca.europa.eu/Lists/ECA-Documents/SR16_08/SR_RAIL_FREIGHT_EN.pdf.

[4] The trend has remained the same in recent years. See "EU invests billions in infrastructure projects-rail gets fair share of the pie": https://www.railfreight.com/railfreight/2022/06/30/eu-invests-billions-in-infra-structure-projects-rail-gets-fair-share-of-the-pie/ ; See also "33 European rail players sign pact: 'massive investment in rail is needed": https://www.railtech.com/policy/2022/02/22/33-european-rail-players-sign-pact-massive-investment-in-rail-is-needed/.

[5] According to the European Environment Agency, rail freight transport causes 15.6gCO2/tonne-km, whereas road transport causes an average of 139.8gCO2/tonne-kilometre. Source: European Environmental Agency. Available online: https://www.eea.europa.eu/data-and-maps/daviz/specific-co2-emissions-per-tonne-2#tab-chart_1 (accessed on April 12, 2022).

[6] See https://ec.europa.eu/commission/presscorner/detail/en/ip_21_7049.

[7] See Figure 44 in Annex 9.1 for the trajectory over time.

On the face of it, the decline in heavy goods transport could weaken the argument for growth in rail transport. However, rail transport of non-heavy goods which also lend themselves well to rail transport, is growing in Europe. The transport of these kinds of goods, more so that heavy goods, requires greater flexibility in order to be competitive with road transport. This view is supported by the rising share of intermodal transport in total rail freight - a trend observable across MS.[8]

1.2 Mandate, objectives and scope of the report

In 2020 the European Commission approved the Green Deal, thereby committing Europe to becoming the first climate-neutral continent by 2050. Reaching this objective requires a transformation of Europe's society and economy towards cost-effectiveness, fairness, and social balance. In particular, one of the main goals is to achieve a 90% reduction in transport emissions by 2050 through intermodality and the utilisation of less polluting transport modes such as rail.

In light of this, the European Commission published its *Sustainable and Smart Mobility Strategy* which sets the ambitious goal of boosting the interoperability of the rail network infrastructure in Europe and to significantly increase both high speed and rail freight traffic by 2050. In order to meet this target, the Commission intends to pursue several objectives such as improving connectivity and access, supporting digitalisation and automation, and making sustainable alternative solutions available to the public and businesses. Furthermore, as a part of the efforts to cut EU greenhouse gas emissions from transport, the Commission foresees a review of the regulatory framework for intermodal transport, including the Directive 92/106/EEC on combined transport of goods between Member States ("The Combined transport directive") for 2023.

In this context, the fitness check of the RG conducted by the Directorate General for Competition of the European Commission in 2019 and 2020 confirmed that RG require a full-fledged review. The revision will be carried out in an integrated approach with the Sustainable and Smart Mobility Strategy and aims at adapting the RG to the full liberalisation of the rail sector particularly following the adoption of the Fourth Railway Package in 2016. The revision is intended to support EU policy priorities in the context of the Green Deal and the increased importance of a modal shift from road to less polluting transport modes such as rail, inland waterways (IWW), and short sea shipping (SSS) in order to meet the Union's emissions reduction target by 2050.DG COMP's general approach for the revision of the RG intends to not only make the railway sector embrace the green and digital transitions, but also to increase competition in rail by removing entry barriers and providing MS and stakeholders with an updated toolbox fully aligned with overarching EU priorities.

To support and inform the Commission's decision, the revision is based on an impact assessment study, a public consultation of citizens and stakeholders, and evidence and quantitative data collected through interactions with the granting authorities of MS, industry experts, and stakeholders.

As a part of these efforts, DG COMP commissioned the consortium consisting of E.CA Economics, LEAR, Sheppard Mullin and UEA ("the Consortium") with an impact assessment support study to underpin the existing impact assessment and the analysis of the different policy options required for the revision of the RG. Experts from the Institute for Transport at the University of Leeds supported the Consortium by providing academic advice.

[8] Transport and ICT (2017, p.4 & p.14) stress that containerisation of goods has reduced frictions between transport modes and enabled RU to compete for the transport of manufactured goods, e.g. from deep seaports. ECM Ventures (2022, p.42) highlight that new entrants that offer flexibility and high service levels are more successful than incumbents in responding to this market trend and have been instrumental to entice customers towards rail.

The study shall cover mostly rail transport and provide factual, analytical and data inputs informing the Railway Guidelines revision process. The focus is specifically on the European rail freight sector, as passenger transport by rail is already covered by the study published by DG MOVE on 17.12.2021 concerning Long-distance cross-border passenger rail services[9] as well as the upcoming study report commissioned by DG MOVE on the application of Regulation 1370/2007 for the passenger segment. Combined transport is already covered by recent publications on combined transport (see MDS Tranmodal Ltd & TRT Trasporti e Territorio srl (2017), ISL & KombiConsult (2017), and KombiConsul et al. (2015)).[10] However, inland-waterway transport and short-sea shipping is also included in the scope of the study to the extent that it concerns the intermodal transport of goods.

This study will be used by the Commission to underpin its planned review of the RG as set out in its inception impact assessment published on 1.1.2021. In this document, the Commission has indicated that it is considering the implementation of the following changes to the RG to keep up with regulatory and market developments and promote a level playing field: Firstly, the adoption of streamlined rules on aid for the coordination of transport, including through higher aid intensities; Secondly, easing market entry as well as the expansion of new or existing market players through access to rolling stock and inland waterway vessels; Thirdly, providing rules governing public service compensation to rail freight transport services.

To keep up with the renewed EU priorities set out in the Green Deal Agenda, the new rules may also extend the scope of the original RG by including all relevant transport operators in the intermodal chain and simplify procedures for aid to coordination of transport.

To assess whether these possible changes are appropriate and effective, the Commission wants the Consortium to provide detailed market information. The study covers all Member States insofar as the required data and information on countries are available. Depending on data availability, the time period from 1 January 2018 until 30 September 2021 is covered, while the time period affected by the COVID-19 pandemic is singled out. A special focus is put on 2019 as the last pre-pandemic year.

The analysis is based on desk research and data collection, including a targeted stakeholder consultation.

The study presents results in the following topics: Overview of State aid and other State support measures for rail freight transport (Section 1.4); Rail infrastructure (Section 2); Modernisation and access to rolling stock (Section 3); Cost, revenue and profitability structure of rail freight services and intermodal transport; Price elasticity of demand for rail freight services ; and Operating State aid (Section 4). Conclusions on the design of State aid for rail freight are collated in Section 5.

1.3 Overview of the rail freight sector in Europe

More than a decade after opening European rail freight markets to competition, it can be stated that the liberalisation process has not been sufficient so far to boost rail transport up to the desired level (see also KombiConsult et al. 2017). While it promoted a large number of new entrants and a healthy level of competition in several countries, constraints in funding prevented the maintenance and expansion of an appropriate network infrastructure. Lengthy maintenance works obstruct availability and entail substantial delays (ECM Ventures 2022, Ministère Chargé des Transports 2021). Priority in the allocation and use of capacity is often given to passenger transport. Moreover, bureaucracy and regulation complicate market entry and expansion across European borders.[11] Some RU complain about a lack of implementation of the common standards

[9] https://op.europa.eu/en/publication-detail/-/publication/34244751-6ea3-11ec-9136-01aa75ed71a1

[10] Parts of this report build on these studies on combined transport.

[11] ECM Ventures (2022, p.82) decry differing national requirements for issuing safety certificates despite efforts by the European Railway Agency (ERA) to harmonise the process.

necessary to facilitate interoperability or deployment of innovations that would improve the efficiency of operations (e.g., digital automatic coupling). Existing interoperable wagons take longer to couple than wagons which are not interoperable. Furthermore, railway undertakings attest a lack of a level playing field, brought about by disregard for the external costs which road transport entails.[12]

The RG will be revised to align them with the policy priorities of the Green Deal, which supports a modal shift from road to rail and other transport modes that are less polluting than road transport. Table 1 below presents the modal share of different types of freight transport – rail, short sea shipping, road, and inland waterways – in Europe as of 2019.[13] The Member States were grouped into four areas depending on their geographical position: West, South, East, or North Europe.

Table 1: Modal Share (based on transport volumes in tonnes) in 2019

Area	Rail	Short Sea	Road	IWW
Western Europe	8.2%	7.8%	76.3%	7.8%
Change (pp*), 2009-2019	0.4	-0.7	0.7	-0.5
Southern Europe	4.1%	17.4%	78.4%	0.2%
Change (pp), 2009-2019	1.9	4.6	-6.5	0.1
Eastern Europe	14.5%	3.8%	79.6%	2.0%
Change (pp), 2009-2019	0.2	1.2	-1.3	-0.1
Northern Europe	11.2%	26.3%	62.4%	0.0%
Change (pp), 2009-2019	-1.4	1.5	-0.1	0.0
EU 24 + CH & NO	8.8%	11.6%	75.6%	4.0%
Change (pp), 2009-2019	1%	1.9%	-3.1%	0.2%

*Source: The Consortium based on Eurostat, variables "rail_go_total", "mar_sg_am_cw", "road_go_ta_tott", and "iww_go_atygo". Notes: The Member States included in each group are i) Western Europe: Austria, France, Germany, Luxembourg, Netherlands, and Switzerland ii) Southern Europe: Croatia, Greece, Italy, Portugal, Slovenia, and Spain iii) Eastern Europe: Bulgaria, Czech Republic, Hungary, Poland, Romania, and Slovakia iv) Northern Europe: Denmark, Estonia, Finland, Ireland, Norway, Latvia, Lithuania and Sweden. Values for Belgium could not be considered due to confidentiality while numbers for Greece refer to 2017, the most recent available year. Percentages refer to the average modal share for each mode of transport in 2019, weighted depending on total freight volumes in thousand tonnes for rail, short sea shipping, road, and IWW transport. *pp: Change in percentage points.*

Freight transport in Europe is dominated by road transport and covers about three quarters of the total transport volume. The rail modal share in Europe (in the total weight of freight transported by road, rail, IWW and short sea) ranges from 4.1% to 14.5%, with the highest share found in Eastern Europe and the lowest in the South. The average modal share is 8.8% across Member States. Outliers worth mentioning are Estonia and

[12] From the public consultation regarding the revision of State aid guidelines, we gather that a majority of respondents considers the 50% threshold for aid compensating the difference of external costs between rail and road as too low, see https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13154-Rail-transport-revision-of-State-aid-guidelines/public-consultation_en.

[13] According to the 2021 Statistical Pocketbook on EU Transport provided by DG MOVE, in 2019 the EU-27 modal share (based on transport volume measured in *tonne-kilometres*) was for at 52% for road, 12% for rail, 4% for inland waterways, 3% for pipelines, 29% for sea, and 0.1% for air. See https://transport.ec.europa.eu/media-corner/publications/statistical-pocketbook-2021_en. Figures based on tonne-kilometres (instead of tonnes) are reported in Annex 9.1. Both alternative underlying metrics of the modal share – tonnes and tonne-kilometres – lead to the same basic result that the rail modal share is low when compared to road transport and that the rail modal share is not-increasing significantly over time. The results differ only regarding the exact level of the rail modal share.

Lithuania, which have a rail modal share of 28% and 28.4%, respectively. The time trend of the rail modal share from 2009 to 2019 is mostly stagnating, with a moderate increase in Southern Europe and a similar moderate decline in Northern Europe. SSS and IWW together cover a larger share of the total transport volume than rail freight in most of Europe, with Eastern Europe being an exception. For country-specific shares, please refer to Figure 43 in Annex 9.1.

Rail freight transport is more common for certain types of goods ("freight categories"), than for others. Table 2 below provides the top 10 freight categories, transported by rail, in Europe according to the NST 2007 classification[14] in terms of tonne-kilometres.

Table 2: Top 5 and 10 rail freight categories in Europe in 2019

Rank	Freight Category	% of total rail transport (in tkm)	Change (pp*), 2009-2019
1	NST 19 – Unidentifiable goods	25.4%	4.2%
2	NST 3 – Metal ores	13.0%	1.4%
3	NST 7 - Coke	10.3%	-4.2%
4	NST 2 – Coal and lignite	9.5%	-2.5%
5	NST 10 – Basic metals	8.7%	-0.4%
Top 5 (%)		**66.8%**	**-1.6%**
6	NST 8 - Chemicals	7.8%	0.1%
7	NST 1 – Products of agriculture	5.8%	-0.1%
8	NST 6 - Wood	4.0%	-0.9%
9	NST 18 – Grouped goods	3.8%	3.0%
10	NST 12 – Transport equipment	3.6%	1.0%
Top 10 (%)		**91.9%**	**1.4%**

*Source: The Consortium based on Eurostat, variable "rail_go_grpgood". Note: The Member States included are: Austria, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and Switzerland. Values for Belgium could not be considered due to confidentiality while numbers for Greece refer to 2020, the most recent available year. *pp: Change in percentage points.*

The top five categories account for about 67% of total rail freight volume. The most rail-transported freight category, unidentifiable goods (NST 19), corresponds to 25.4% of total rail freight volume in Europe. Goods in this category are mainly transported in containers and swap bodies, underlining the growing importance of intermodal transport.[15] Moreover, the share of intermodal transport is likely to be higher as other NST categories can also be transported in containers (e.g., food).

The next four positions cover about 42% of rail freight volume and consist of heavy bulk goods (metal ores, coke, coal, and basic metals) which are typically transported via

[14] NST 2007 is a standard classification of goods for transport statistics published by the Economic and Social Council of United Nations. See https://unece.org/fileadmin/DAM/trans/doc/2008/wp6/ECE-TRANS-WP6-155a1e.pdf.

[15] In the case of Germany, for instance, 93% of the volume for Unidentifiable goods (NST 19) in 2019 is classified under containers and swap bodies operations. See Statistisches Bundesamt (Destatis). (2022). Beförderte Güter. https://www-genesis.destatis.de/genesis//online?operation=table&code=46131-0007&bypass=true&levelindex=0&levelid=1652175988775#abreadcrumb.

block train operations.[16]The next five freight categories, those in the second half of Table 2, contribute only 25.1% to the total freight volume transported via rail in Europe. The goods included are chemicals (NST 8), Agricultural products (NST 1), wood (NST 6), grouped goods (NST 18), and transport equipment (NST 12). The latter category includes automotive industry parts and products as well as other transport equipment. All in all, the top 10 most rail-transported goods represent 91.9% of total rail freight volume in Europe. In line with the above finding, we observe declining shares of transported bulk goods and subsequently, an increase in the share of goods transported by containers.[17] This pattern holds true for most Member States. For further details, please refer to Annex 9.2.

Rail freight transport incorporates trains with different types of loading units (LUs) and different composition of wagons. The role of each train type varies from one Member State to the other. This study follows common industry practice and considers block trains, single-wagon operations, and intermodal transport as the three mutually exclusive categories exhausting the entire market. As defined in Annex 2, block trains refer to trains typically transporting a large number of traditional freight wagons with a single commodity for a single client, typically from door to door. Meanwhile, **single-wagon** operations carry wagons for different clients in a single train and require local feeder and distribution services. Lastly, **intermodal transport** describes rail freight transport using an intermodal loading unit such as containers or swap bodies.[18] In this case, the rail service constitutes only a single leg in an intermodal transport chain which includes other modes such as road or inland waterway. For the purpose of this study, we consider the rail leg of this type of operation to be equivalent to a block train service operating between two major terminals.

In reality, however, such a categorisation is somewhat simplistic as it does not exhaust all existing combinations of train types and loading units present in the market. For instance, it excludes intermodal single-wagon operations.[19]

Figure 1 below presents the share per type of loading unit in total rail freight volume across Member States in 2019.[20] The share of rail freight in containers and swap bodies ranges from 1.4% in Latvia to 80% in Greece.[21] The average value across Europe is 27.5%. Typically, these intermodal loading units are transported on dedicated intermodal block trains (often called "combined transport" in the industry, even though this does not fully align with the official EU definition of combined transport).

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[16] Rail transport has traditionally been a preferred mode of transport for these categories of goods, as it can exploit its competitive advantages in the transport of large volumes. An international comparison shows that the rail modal share tends to be high in such economies which rely relatively strongly on the primary sector and heavy industries (IEA 2019, p. 45). However, as the European economy will develop further away from heavy industries towards high-tech industries and the service sector, demand for rail transport of such heavy bulk goods will likely decrease.

[17] According to VDV, the share of intermodal traffic, typically represented by containers has increased compared to block train traffic carrying bulk goods since 2015, see: https://www.vdv.de/schienen-gueterverkehr-als-garant-des-klimaschutzes.aspx; Containerised transport as a proportion of total rail freight transport has increased since 2017 in Europe, see: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Freight_transported_in_containers_-_statistics_on_unitisation; UIC highlights the increase in intermodal rail freight, represented by containers and swap bodies in Europe since 2005, "*Combined Transport in Europe (2018)*", see: https://uic.org/IMG/pdf/2018_report_on_combined_transport_in_europe.pdf.

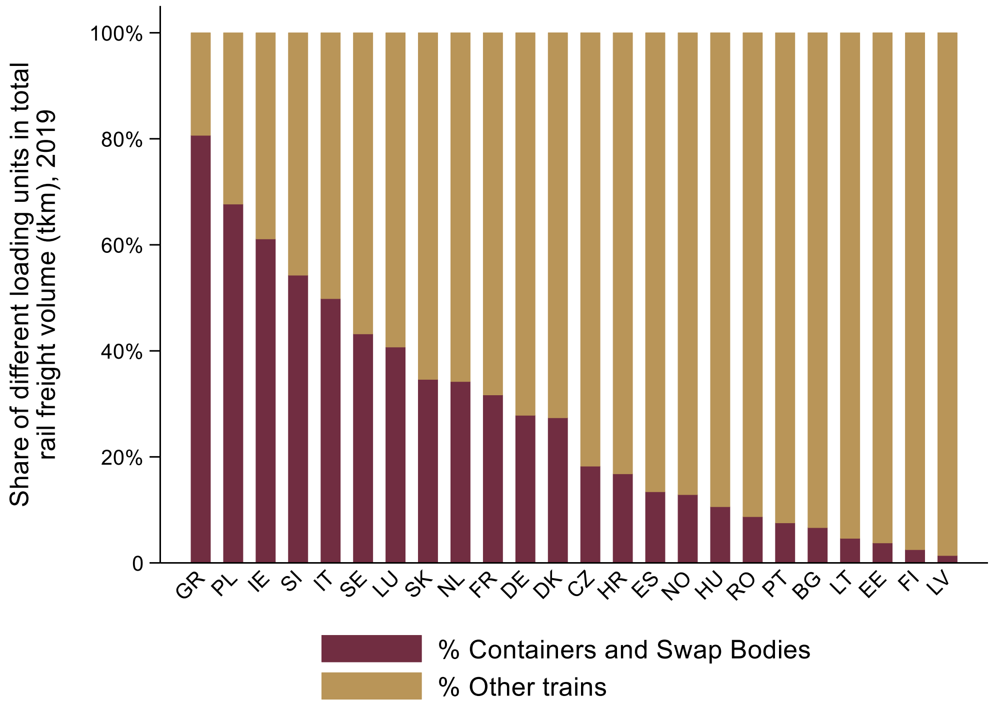
[18] A swap body is one of the types of standard freight containers for road and rail transport. It can be placed on the same kinds of trucks, trailers, and railroad cars designed for shipping containers. However, given that it does not have upper corner fittings, it is not stackable and thus requires special handling when transported by rail. Another intermodal loading unit is semi-trailers.

[19] For an example, please refer to Annex 25.

[20] Please note, however, that these Eurostat figures are subject to statistical limitations. Nonetheless, despite some uncertainty regarding the precise figures, the overall picture is meaningful. See UIC (2020, p.10). Unfortunately, there is no complete database providing satisfactory data per train type across Member States. Therefore, caution in the use of the presented figures is advised.

[21] In 2019, based on the variables "rail_go_contwgt" and "rail_go_typepas" (Eurostat), the share of accompanied and unaccompanied transport of semi-trailers and lorries in EU-23 corresponded to 0.3% and 6.1%, respectively (note that these numbers do not consider BE, IE, LU, AT, and ES due to confidential or missing data). We do not include data on semi-trailers and accompanied lorries transported by rail into this analysis because their overall share is relatively low and data availability does not permit a reliable analysis.

Figure 1: Share of rail freight volume by loading unit in 2019

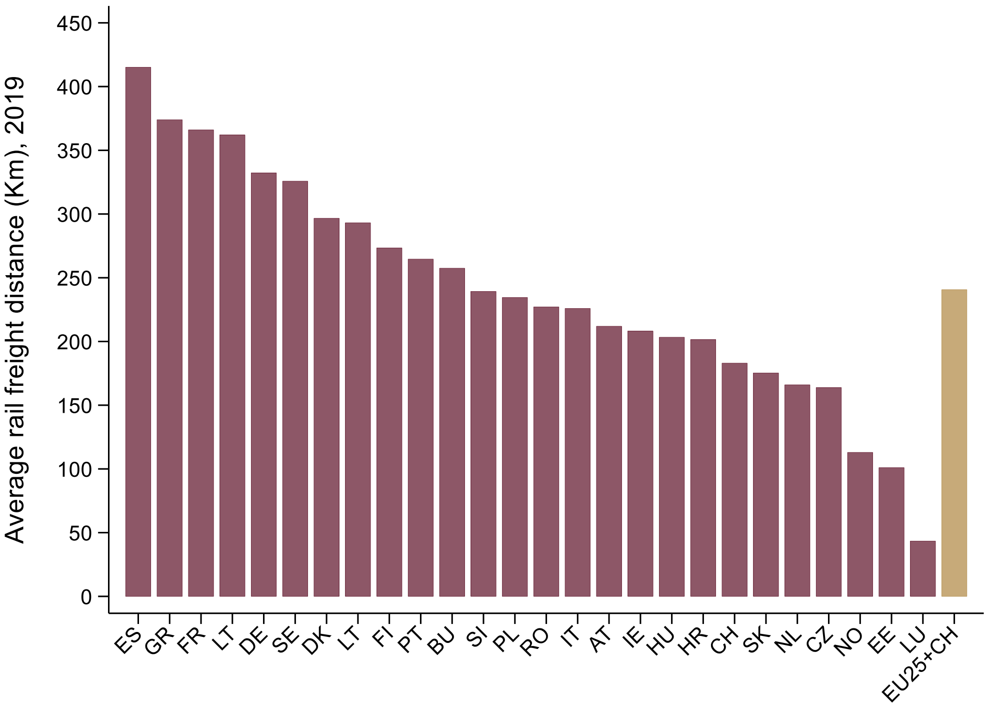


Source: The Consortium based on Eurostat, variables "rail_go_contwgt" and "rail_go_typepas". Note: Values for Austria, Belgium, and Luxembourg could not be considered due to confidentiality.

The distance travelled by a tonne of freight on rail within each country is represented in Figure 2 below. It shows that across countries, the average distance ranges from 43 km to 415 km, with a mean of 241 km. Note that this distance is to be understood as the average distance travelled by one tonne of freight within the borders of a country.[22] Disregarding transport beyond national borders leads to a downward bias and affects smaller countries more than larger ones. The figures should therefore be approached with caution as actual average distances travelled are likely to be higher. For information on the average travelled distance for international intermodal transport, please refer to Annex 9.3.

[22] Trains could be expected to travel further than a tonne of freight because international trains are only reported for the distance within country borders.

Figure 2: Average distance per country in 2019



Source: The Consortium based on Eurostat, variable "rail_go_typepas". Numbers include domestic, international, and transit rail freight transport. Note: The numbers were obtained by dividing total rail freight in tkm by total rail freight in tonnes for each country in 2019. Values for Belgium could not be computed due to confidentiality.

Finally, we grouped Member States into four different clusters of countries depending on the market share of the incumbent: 0%, 27-60%, 61-90%, and exceeding 90%. Table 3 below provides the market share of the domestic incumbent, alongside with additional relevant characteristics such as the number of active freight railway undertakings, the ratio between the number of RU and transported volume in billion tkm, and the Herfindahl-Hirschman Index[23] (HHI) as of 2018.

Table 3: Supplier structure of rail freight in Europe in 2019

	1) Oligopolistic structure with non-incumbents only	**2) Mostly competitive**	**3) Dominating domestic incumbent**	**4) Near monopoly of the domestic incumbent**
Countries	DK, EE, PT	BG, DE, HU, IT, NO, PL, RO, ES, SE, NL*	AT, BE, HR, CZ, FR, LV, SK, SI, CH	FI, GR, IE, LT, LU
% Incumbent	0%	27-60%	61-90%	>90%
No active RU	2-5	6-291	4-96	1-2
RU/Billion tkm	0.8-2	0.5-4.4	0.3-5.9	0.1-13.9
HHI 2018	7641-9662	2116-3788	3422-7372	9451-10000

[23] The Herfindahl-Hirschman Index is a measure of market concentration. It is calculated by squaring the market share of each firm (in %) competing in the market and then summing the resulting numbers. The HHI ranges from 0 to 10,000. A market with an HHI of less than 1,500 is considered a competitive market, an HHI between 1,500 and 2,500 is moderately concentrated, and an HHI of 2,500 or greater is highly concentrated.

Change (%) of volume in tkm, 2009-2019	-27.1%	23.5%	3.5%	23.7%
Change (pp) in rail modal share, 2009-2019**	-2.6	1.1	1.5	5.7
Average State aid per km of line (ct/km), 2012-2019* **	0.99	2.09	4.64	4.04

*Source: The Consortium based on IRG's 9th and 8th Market Monitoring Report and Eurostat (variables: "rail_go_total" and "rail_if_line_tr"). Notes: *Regarding the Netherlands, the foreign incumbent's market share falls in the specified range while there is no domestic incumbent in the market anymore. **pp: Change in percentage points (not country-weighted). *** State aid data is available only for selected countries in each cluster: i. Denmark ii. Bulgaria, Germany, Hungary, Italy, Netherlands, Poland, Romania, Spain, and Sweden. iii. Austria, Belgium, Croatia, Czech Republic, France, and Slovakia. iv. Finland, Greece, and Luxembourg. Data on State aid for Switzerland is not available. The measure involves only actual and budgeted State aid awarded directly by MS and not State aid awarded via EU schemes such as the regional development fund. Moreover, figures refer to total aid (investment and operating aid) including infrastructure aid. In order to relate it to the network length in km, total State aid per cluster was divided by each cluster´s average length of lines between 2012 and 2019.*

The first cluster encompasses Member States, whose rail freight supplier structure is oligopolistic with non-incumbents only. In fact, there was no independent incumbent operating freight transport in any of these Member States as of 2019. The respective number of active freight RU ranges between two and five, the HHI indicates a high concentration, and rail freight volumes decreased strongly from 2009 to 2019. State aid volumes (per km of network) in the period from 2012 to 2019 were the lowest among the clusters.

The second cluster includes competitive supplier structures and contains countries where the domestic incumbent owns a market share of between 27-60%, together with a larger number of active freight RU. Here, Germany and Poland report the highest numbers, reflecting a relatively high level of competition. The HHI ranges from 2,116 to 3,788, indicating a low concentration in the rail freight sector across the MS in the cluster, which experienced increasing rail freight volumes but a rail modal share remaining constant over the period from 2009 to 2019, i.e. the rail freight sector only grew in line with the total transport sector. State aid volumes from 2012 to 2019 were relatively low, but higher than in the first cluster.

Finally, the third and fourth cluster of countries contain MS, whose domestic incumbent is either strongly dominant or a near monopolist. In the former cluster the incumbent has a large market share but is still under the threshold of 90%, while in the latter it owns almost all of the national rail freight volume. These market dynamics are also reflected in the number of active RU: In the third cluster, the number of rail freight undertakings ranges from 4 to 96, while in the fourth cluster the sector is served by only one or two rail freight operators. Further evidence is provided by the HHI, which reaches a maximum value of 7372 in the third cluster and of 10,000 in the fourth. For deeper insights into each country's supplier structure, please refer to Table 59 in Annex 9.4.

With respect to the evolution of transported volume and rail modal share, however, the clusters exhibit important differences. Firstly, MS belonging to the third cluster did not experience significant growth in rail transport volumes and modal share between 2009 and 2019. The most significant growth is instead in the fourth group, with an increase of 27.7% in transport volume and 5.7% of the rail modal share. Finally, the clusters are similar in the amount of State aid received from 2012 to 2019, which is high in both clusters.

This final report provides factual, analytical and data related input and shall serve as a contribution to the review of the Guidelines. The analysis is based on the answers to specific questionnaires received from numerous targeted stakeholders in twelve EU-

Member States and Switzerland, including European umbrella associations, infrastructure managers (IM), national market regulators, inland waterway operators, stock leasing companies, granting authorities, railway undertakings and intermodal operators. In addition, the analysis reflects the data provided by many national Registration Entities of the EU Member states. Furthermore, various interviews were conducted with stakeholders, which resulted in a total number of 80 responses.

The structure of the report is as follows: Section 1.4 provides an overview of State aid in the rail freight sector. Section 2 describes the current situation of rail infrastructure and essential service facilities, intermodal terminals, and private railway sidings. The conditions of existing rolling stock, its access, interoperability, and modernisation as well as the acquisition and retrofit of rolling stock and State aid for combining sustainable modes of transport are presented in Section 3. The cost, revenue and profitability structure of rail freight transport (both of rail only and of intermodal transport) are assessed in Section 4. This Section also includes the estimates of price elasticity and operating aid, under which the financial incentives for structurally loss-making rail services, the proportionality and necessity thresholds, aid to reduce the cost of access to infrastructure and start-up aid for new services are examined. Finally, Section 5 provides the impact of State aid on final prices, the efficiency of State aid measures, and a collection of the main conclusions related to State aid.

Annexes include the literature references, study questions, data bases, stakeholders participating in the survey, survey questionnaires and interview guides.

1.4 Overview of State aid in the rail freight sector

1.4.1 Methodology

To better understand the nature of State support measures for rail freight and intermodal transport services and address study question 27[24], a database of State support measures implemented across the European Union, Switzerland and the United Kingdom has been constructed.

First, a database of 156 relevant European Commission State aid decisions was collated from the European Commission’s case search tool25. This database was constructed using the Commission´s transparency platform by using the ‘competition case search function’ to filter out cases involving NACE code H.49 – Land transport and transport via pipelines and the NACE code H-52 -Warehousing and support activities for transportation’. This was then cross referenced against another list compiled using the ‘competition case search function of ‘Art. 93 TFEU transport’ cases, and a third list of any decision which lists transport as a secondary legal basis.

Each decision resulting from this process was then read to access its relevance to four categories: i) decisions which generally support rail freight transport services; ii) decisions which specifically cover passenger and freight rolling stock; iii) decisions which support intermodal infrastructure and intermodal services; iv) decisions which provide investment promoting greater safety, the removal of technical barriers and the reduction of noise and other environmental pollution. Decisions funded entirely from EU sources were then removed from the sample. The remaining decisions were then grouped into 95 separate State aid measures.

This was then supplemented with further desk research (internet search and review of relevant academic reports) to ascertain State support measures in Switzerland and non-State aid support (general measures and de minimis aid). These measures proved more

[24] See Q27 of technical specifications in Annex 3: ‘What are the State Support measures in the EU and in Switzerland that are designed to directly support: a) rail freight transport services b) passenger and freight rolling stock c) intermodal infrastructure and intermodal services pursuing the modal shift of freight traffic from road to rail or maritime or inland waterway; and d) investments promoting greater safety and the removal of technical barriers and the reduction of noise and other environmental pollution.

[25] For further information on this tool see: https://ec.europa.eu/competition/elojade/isef/index.cfm?clear=1&policy_area_id=3.

difficult to identify as they are not contained within a central database, equally no publicly available record of de-minimis aid could be identified. 9 non-State aid support measures were identified and added to the database.[26]

We predominately observed schemes open to freight operators and terminal owners although did not exclude schemes open to other types of beneficiaries from data collection and we also observed a small minority of schemes which were open to other beneficiaries such as research facilities and rolling stock producers.

The database has been analysed throughout the report: Section 1.4.2 provides a descriptive overview of the database; Section 1.4.3 leverages this database with empirical data on the extent of the modal shift to analyse whether there is a plausible relationship between relative increases in the modal share of rail, short see and inland waterway freight shipments and the provision of State aids in a Member State. This analysis is performed with comparison of levels and changes in scheme numbers and budget supports, compared to modal share evolution. The sources of information used are government and private data from relevant stakeholders, as reported by Eurostat. The beginning period of 2012 is selected to match the beginning year of the database. The concluding year of 2019 is selected to avoid COVID-19 pandemic effects. The analysis is inherently limited by the highly aggregated nature of the data and the difficulty of identifying the counterfactual that would have existed in the absence of State support measures. Throughout the report, but particularly in Sections 2.6, 3.6 and 4.8 we use the database to assist in a review of existing ex-post.[27] Ex-post analysis was gathered from relevant policy documents such as reports from national authorities and State aid decisions. We have drawn policy conclusions from our findings in Section 5.

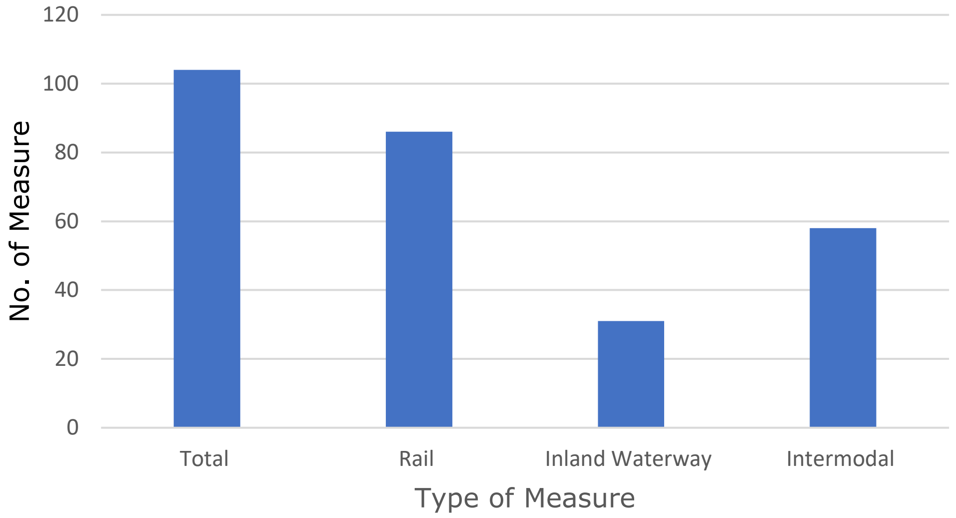
1.4.2 Review of State measures to support rail freight, intermodal infrastructure and services, safety, removal of technical barriers and reduced noise and environmental pollution

As Figure 3 illustrates, the Consortium identified 104 State support measures[28], 88 of which related to the rail transport sector (88/104 84.6%)[29], 31 of which related to the inland waterway sector (31/104, 29.8%)[30] and 58 of which related to intermodal infrastructure and operations (58/104, 55.8%%)[31] [32].

[26] Support Schemes within the United Kingdom have been classified as state aid support schemes, as the three schemes in operation within the United Kingdom were all approved under EU legislation before the United Kingdom left the European Union.

[27] Q28 What is the evidence (e.g. reports), if any, of the impact of those measures in respect to the objectives pursued, in particular on fostering modal shift to rail?
[28] See Annex 7 for a list of all schemes identified. The Consortium identified 95 state aid schemes and 9 non-state aid schemes.
[29] These measures were identified across 18 Member States (Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, France, Germany, Greece, Hungary, Italy, Luxembourg, the Netherlands, Poland, Romania, Slovakia, Slovenia, Sweden), the United Kingdom and Switzerland.
[30] These measures were identified across 12 Member States (Austria, Belgium, Croatia, Czech Republic, France, Germany, Hungary, Italy, Luxembourg, Romania, Slovakia, Sweden), the United Kingdom and Switzerland.
[31] These measures were identified across 16 Member States (Austria, Belgium, Croatia, Czech Republic, Finland, France, Germany, Hungary, Italy, Luxembourg, the Netherlands, Romania, Slovakia, Slovenia, Spain, Sweden) the United Kingdom and Switzerland.
[32] Note that these scheme types are not mutually exclusive. For example, a scheme may allow applications from both the rail freight sector and from the inland waterway sector.

Figure 3: Number of State Support Schemes by Category (all Member States, CH, and UK)

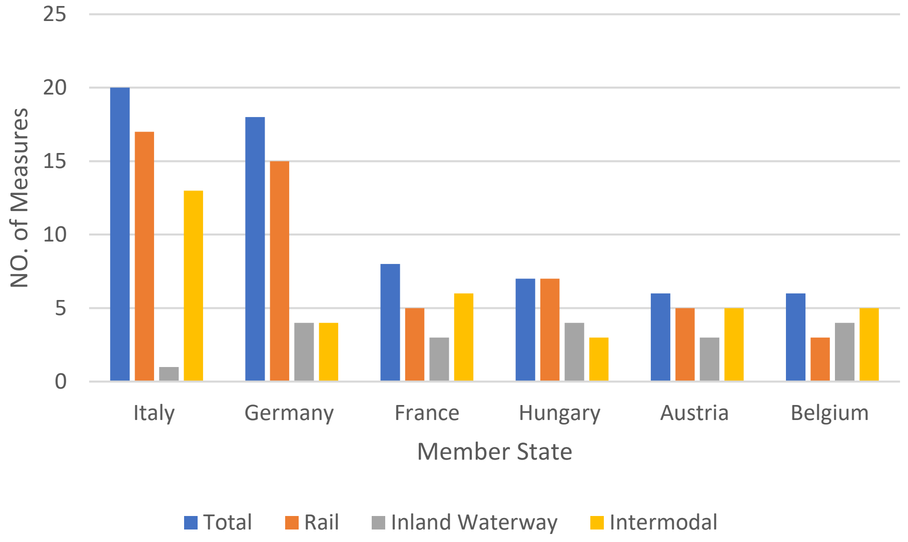


Source: The Consortium.

The sample included 48 (48/104,- 46.1%) operating aid State support measures and 58 (58/104, 55.8%) investment aid State support measures.[33] 26 (26/104, 25%) State support measures identified were individual aid decisions and 78 (78/104, 75%) State support measures identified were schemes (i.e., willing to accept multiple participants).

As Figure 4 illustrates, within each Member State there was a significant variation in the type of schemes implemented.

Figure 4: Categorisation of State Support Scheme, Member States with the highest number of support measures



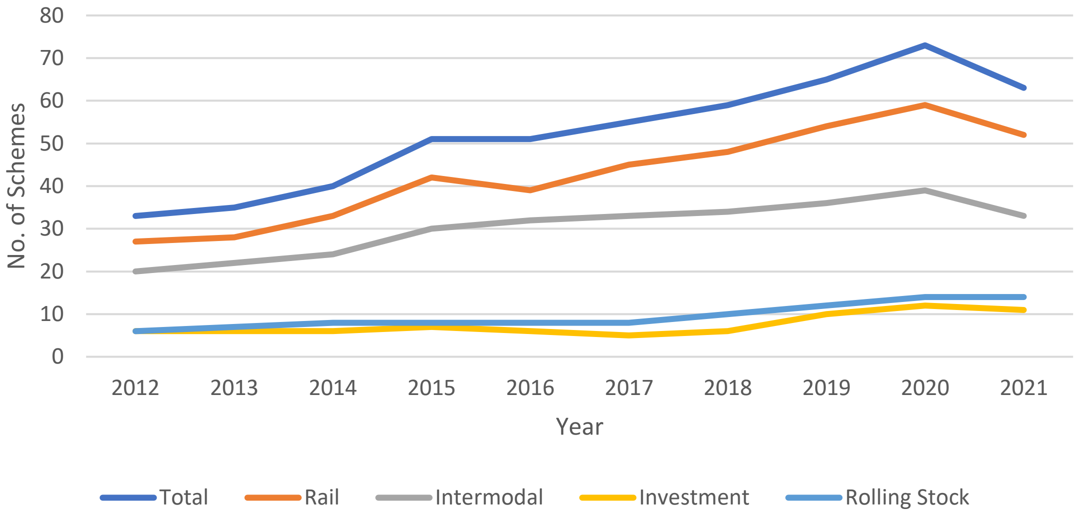
Source: The Consortium.

For example, in Germany 83.3% of schemes allowed applications from the rail freight industry and 22.2% of schemes had an intermodal focus, whereas in France 62.5% of schemes allowed applications from the rail freight industry and 75.0% of schemes had an intermodal focus.

[33] Note that these scheme types are not mutually exclusive. A scheme may offer both investment aid and operating aid.

As depicted in Figure 5, the total number of active measures increased by 90.91% over the observed time period (2012-2021) from 33 at the end of 2012 to 63 at the end of 2021.

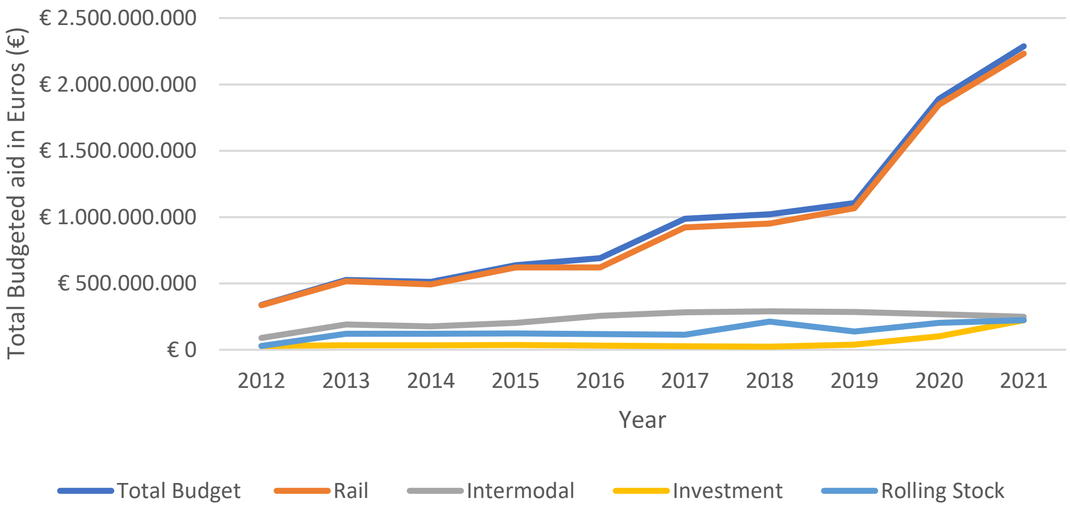
Figure 5: Number of State Support Measures in operation per year



Source: The Consortium.

The number of active measures needs to be put in context with the budgetary levels of respective measures, which are sometimes very low and in the context of federal states, where the number of measures could be high but with low budgets for an average measure, meaning the aggregate level of support may not be directly associated with the number of measures. However, as Figure 6 depicts, the budgets of these measures over time increased by a far greater proportion, 577%.

Figure 6: Budget of State Support Measures per Year



Source: The Consortium.

Significant increases were observed across rail freight schemes, intermodal schemes, rolling stock schemes and schemes which support investments promoting greater safety, the removal of technical barriers and the reduction of noise and other environmental pollution.

One possible explanation for the increase in schemes between 2012 and 2021 is that our dataset was primarily assembled by reviewing data from decisions from 2012 onwards, therefore for the first few years in our series it is possible that data has been omitted (for example, a decision approved in 2010 may contain budget datapoints for

2012, 2013, 2015). However, the percentage increase in the last 5 years (131.5%) is greater than the increase in the first 5 years (103.9%) which suggests that budgets and numbers of schemes are still genuinely still increasing. Despite this however, the correlation between EU 27 modal shift and the budgets of these measures over the period is negative. This is because the modal share of rail in freight transport decreased by 1% between 2012 and 2019.

Both rail and intermodal measures saw a sharp decrease in the number of active measures in 2021 compared to 2020 as 12 measures ended in 2020. Five COVID emergency support measures were introduced in 2020-2021 and three of these measures were still active in 2021, suggesting that the pandemic was not a significant factor in this decrease, and the decrease.

CONCLUSIONS:

104 State support measures supporting rail freight and the modal shift of freight traffic away from road to more environmentally friendly modes of transport (rail, inland waterway and maritime) were identified:

- 33 schemes in operation in 2012 and
- 66 schemes in operation in 2021 suggesting these schemes became significantly more popular over the period.

There is diversity in the modes of transport supported:

- 88 schemes supporting the rail freight transport industry,
- 58 schemes supporting intermodal infrastructure,
- 20 schemes replacing or upgrading rolling stock and
- 16 schemes promoting greater safety, removal of technical barrier, noise and other environmental pollution were identified.
- 10 of the support schemes identified related to maritime, and
- 31 of the support schemes identified related to inland waterways.

The number of schemes in operation and their budgets increased dramatically between 2012 and 2021:

- 33 schemes were in operation in 2012, 63 schemes were in operation in 2021: a 90.90% increase.
- The schemes had a total annual budget of €338.06 million in 2012 and €2.29 billion in 2021: a 577% increase.

1.4.3 Evolution of the modal shares of rail, inland waterways and short sea shipping and of State support levels

Building on the support schemes data that has been described above, it is worth looking at the evolution of shares of non-road freight transport to see whether there is any headline relationship, at a national level, between the schemes and any modal effects. However, the systematic and EU-wide data available on modal shares is at a national level, which inherently limits the capacity to draw definitive conclusions about individual schemes. The purpose of these State support schemes[34] is to facilitate increased non-road modal share with the public funds used most effectively and not replacing private funds when those would alternately have been sufficiently profitable for a given task. Assessing the relationship between State support levels and the shift to non-road freight transport is a complex exercise, largely due to the complexity of the drivers of non-road transport. These drivers include final cost to shippers of moving their goods, appropriateness of goods to non-road transport, the shipper needs for speed, the relative cost of route access (with rail access charges compared to many free roads for trucking), the location of intermodal terminals and their proximity to needs, the length of journey for each shipment, the volume and mass characteristics of shipments, etc. We focus here on the primary modes of non-road transport: rail, short sea shipping (SSS) and inland waterways (IWW).

[34] The related schemes and measures are selected according to the criteria of Section 2.4.1.

In principle, State aid can enable the provision of facilities that might not otherwise be constructed, when it is used for infrastructure enhancement and expansion. For example, commercial rationales might not be sufficient to motivate the opening of rail or waterborne transfer facilities that could be construed to support the competing mode of road, or provisions of road transfers may be too small to merit the investment, while still considered worthwhile for environmental reasons. International Union of Railways (UIC) (2020, p. 26)[35] suggests that the top three bottlenecks for intermodal transport are insufficient train path capacity for intermodal transport trains (74% of respondents), interoperability deficits of rail infrastructure (78% of respondents), and costly last miles (80%). Lack of open-access terminals (37%) and lack of terminal capacity (66%) are also noted as significant bottlenecks, which is further discussed in Chapter 4. These survey findings can be construed as suggesting that failings in infrastructure and high costs (e.g., for transferring loads) are important limitations for intermodal transport. State supports to address these bottlenecks may be expected to reduce the intensity of selected bottlenecks, while others may be addressed more directly through other means (e.g., to the extent that detailed terms and conditions for access are bottlenecks).

We focus on a descriptive analysis of the evolution of freight non-road transport at the country level and relate this (without causal link estimation) to the amount of related State support granted in each Member State. The measure used is thousand tonnes of freight.

We do not expect a large or significant impact of State support is likely to be identified. Impacts of other factors are likely to be much greater. Major factors that have affected the modal share of non-road transport in recent years include levels of State support that are not intended specifically as non-road transport support, changes in the road price, the increased transport over Silk Road, the availability of drivers, among others. We consider these and other possible factors as very important, and are not able to control for these in the analysis. In conclusion, we cannot infer causal relationships from the data currently available and that has been reported here.

While the share of rail, IWW and SSS as a share of overall freight transport has fallen somewhat between 2012 and 2019,[36] the decline of 0.5 per cent in the EU disguises the fact that the volume of rail transport increased by 1.5 percent over the same period, while the volume of IWW fell by 3.2 percent.[37] Figure 7 shows non-road modal shares across the EU.[38] There is substantial cross-country variation in the level of non-road modal shares between countries compared with the number of State support schemes for non-road transport. It is evident that some countries with high non-road modal shares have few support schemes, and the counties with the most support schemes do not necessarily have high non-road modal shares. Figure 8 shows that the level of change in the rail, IWW and SSS share of freight between 2012 and 2019, revealing substantial variation between countries. Thus, both levels and changes vary across Europe. A full set of reasons for this variation between countries are beyond the scope of this report, but can include factors such as rail and road density, which freight corridors intersect a country, intensity of transit transport, the proximity of maritime and inland waterway transport, and the nature of products produced, used and ultimately consumed at different locations that requires freight transport. Most of these sources are related to factors that have not changed substantially between 2012 and 2019, such as route density or geographic positioning, even if geopolitical contexts may affect the volumes passing through different paths. In contrast, State aid and other supports come and go more frequently. Levels of State support for non-road transport in Europe have been substantial over many years now.

Comparing the number of schemes on State aid over the period 2012 to 2019 and the non-road (rail, IWW and SSS) share over the same period does not reveal any strong

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[35] UIC Freight Department, 2020 Report on Combined Transport in Europe, November 2020.

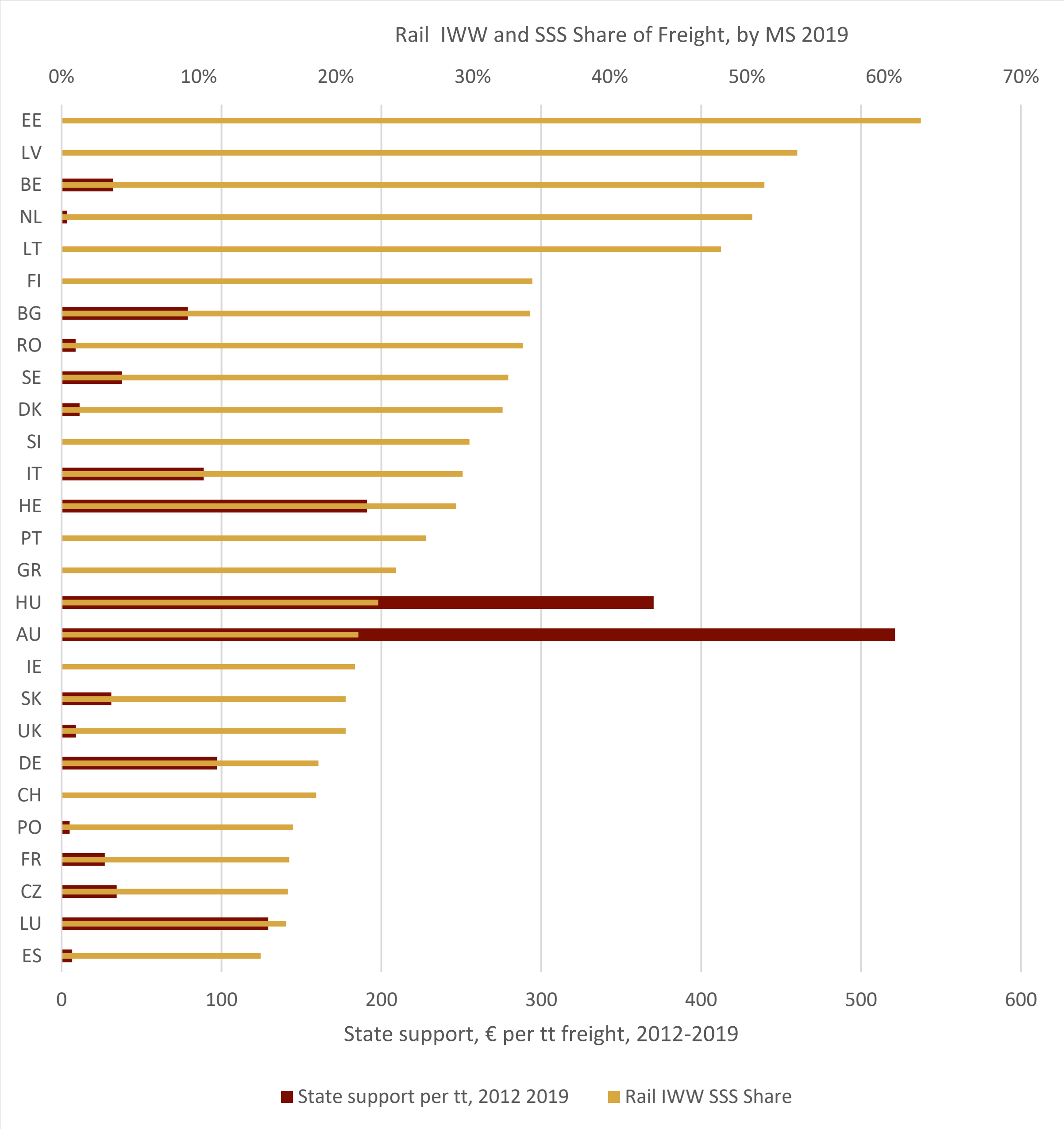
[36] 2011 is chosen as the start time due to the financial crisis in 2010 having affected the modal split in ways that were atypical of the following years.

[37] Part of the IWW decline may be due to lower than normal water levels on waterways affected by lack of rain during 2019.

[38] Rail data for Belgium is not reported.

and simple relationship. Both the number of State support schemes and the share of rail, IWW and SSS freight vary substantially across Member States and Switzerland and United Kingdom (UK). The volume of spending in State support schemes in a Member State is correlated at -0.28 with the change in modal share for rail, IWW and SSS.

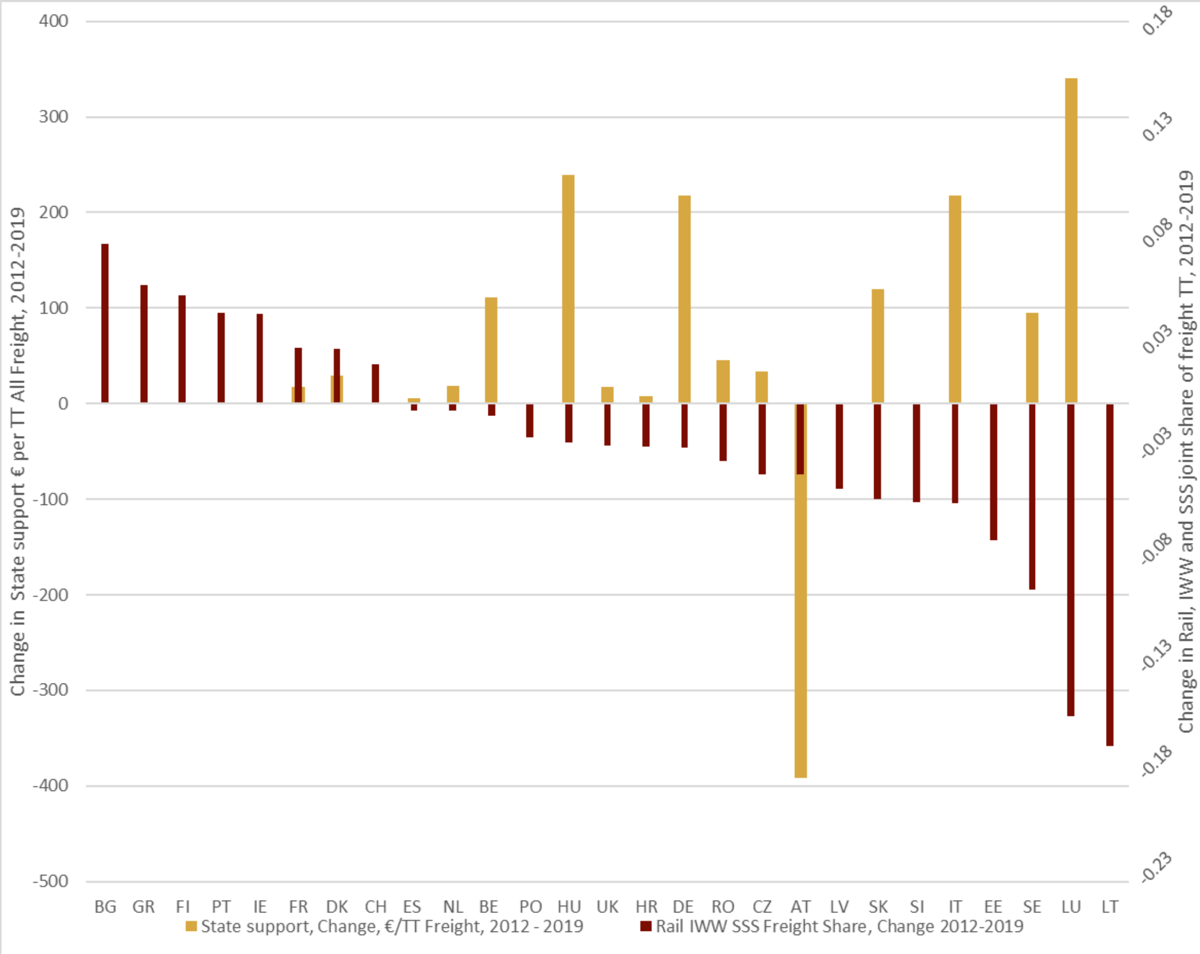
Figure 7: Rail, IWW and SSS share in 2019 compared to State support scheme levels (2012-2019)



Source: The Consortium.

The changes in share of non-road freight in total freight are illustrated in Figure 8. This shows that the largest declines in non-road modal shares- of rail, IWW and SSS between 2012 and 2019 are for Estonia, Latvia, Lithuania and Sweden. The Baltic states started the period with among the highest rail modal shares of all Member States, exceeding 35% according to Eurostat figures for t-km 2012. Thus, their decline may potentially be seen as a movement towards a more typical share of non-road freight. The seven Member States with the largest increases in rail, IWW and SSS modal share experienced gains between 1-7%.

Figure 8: Change in Rail, IWW and SSS of freight compared to change in EUR State support per TT freight: 2012-2019



Source: The Consortium.

There is a correlation of -0.23 with respect to the change in State aid spending between 2012 and 2019 per TT and the change in shares of rail, IWW and SSS. These calculations are based on State support spending from 2012 to 2019 and the per cent difference in shares of non-road transport between 2012 to 2019. The rationale for this comparison is to focus on long-run impacts at the Member State level, for which we have data. Note though that if more focused geographic and shipment-specific data were available, this would be helpful for considering impacts of specific State supports, as one would generally expect the impact to arise after the building out and entry in service of the assets for which State support is provided as well as for the particular operational activities that receive State support. For example, State support for a scheme that provides support to an activity a particular place would be likely to have the most measurable effects on data for that location, rather than national data. The lack of a firm positive correlation between support schemes for non-road freight and increases in the non-road freight share at a national level does not mean that specific schemes have no effect: More focused geographic and temporal interview evidence can indicate otherwise, as with the reversal of a decline in rail share apparently arising from building a new terminal at Bettembourg in Luxembourg.[39]

Greater granularity of data would allow increased associations between different types of State aid and State support and the relative impacts of each. Current data is insufficient for such an analysis.

[39] See Annex 14 for indicative support for the developments at Bettembourg.

The data at the national level is fundamentally insufficient for dealing with the complexities of non-road transport via a regression analysis. Much more detailed data is needed, about volumes by intermodal terminal and the origin and destination of freight to have a possibility to examine different State support schemes and their effects. Moreover, the data must be sufficiently fine-grained to distinguish operating and investment schemes at the terminal level, as these will have different lags in their effects, with operating aid having potentially more immediate effects than investment aid, which will not necessarily have effects until competed, e.g. when a new terminal is constructed over a number of years. Finally, much of the non-road transport occurs in neighbouring countries from those of the terminals. Additional complexity will arise, in particular, through known challenges in estimating the counterfactual of non-road freight shares in the absence of State interventions, as well as the complications that arise from State supports that would not count as State aids. Moreover, the data on non-road modal shares is national while State investment supports are focused on (multiple) particular assets, like terminals, making any interpretation of estimates particularly difficult. Until more detailed, local area data is available for many locations, including both those that receive aid and those that do not, the extent of true transport volumes along routes by type of good transported and transport mode regression estimations are unlikely to provide conclusive findings.

CONCLUSIONS:

The changes in share of non-road modes in total freight transport vary across Member States, with some experiencing significant declines over 2011-2020 and some increases.

The spending on State support for non-road transport, as well as the number of schemes, varies across Europe, with:

- Some countries with high non-road modal share (or relatively high changes in share) have no schemes;
- Some countries with low non-road modal share (or relatively negative changes in share) have schemes.

The complex factors affecting transport combined with data constraints make it difficult to identify exactly which factors affect modal shift changes. Further fine-grained data collection may be needed to follow the evolution of non-road transport activity more closely.

1.4.4 Evaluation methods

This Section summarises the methods to measure the extent of success or failure of State aid schemes in the rail freight transport sector used in existing ex-post evaluation studies carried out by the Commission and other MS.

The primary objective of State aid evaluation is to assess the effects of a State aid scheme using ex-post evidence. The RG do not require MS to evaluate their subsidy measures for rail freight, but some MS prepare evaluation reports. Such assessments typically provide an overview of the scheme objectives, results achieved for the period of assessment, the budget spent and key result or performance indicators, depending on the desired output of the scheme and aid recipient industry. These evaluation tools can be grouped into measures of effectiveness and measures of efficiency of State aid schemes and are presented in detail below.

Effectiveness assesses how successful the State aid schemes have been in achieving specific outcomes such as modal shift of volumes from less-desirable modes of transport such as road to more-desirable modes of transport such as rail. The most commonly used measure is an estimate of the transport volume which has been shifted to rail due to State aid. Some studies provide a range of transferred volumes where the upper bound considers the entire useful life of transport equipment purchased using State aid,[40] and the lower bound considers transferred volumes only during the evaluation period, disregarding any useful life considerations.[41]

Other examples of effectiveness measures estimating modal shift include:

- Correlation between the proportion of goods moved under the support of a scheme and change in transported volumes across the desired transport modes.[42]
- Traffic volumes shifted as a proportion of total transported volumes across the desired transport modes, proxying the extent to which the scheme has been successful in promoting a modal shift to the desired transport modes.[43]
- Comparison between the change in transported volumes for a specific MS and the change in transported volumes for the rest of the EU in the relevant evaluation period, providing insights on how a scheme has worked in specific country relative to the rest of EU.[44]

Note that these measures do not allow identifying the causal impact of aid on modal shift, which often requires an econometric analysis. Such analysis can control for exogenous factors (other than the aid itself) that affect the modal shift and thus can isolate the sole impact of State aid. Compared to descriptive statistics, econometric analysis often requires more input data. For an overview of available methods, data and administrative requirements see the Commission's staff working document "*Common methodology for State aid evaluation*."[45]

Efficiency of State aid measures considers the ratio between the value of subsidies granted by public authorities (the input) and the change in the volume transported by rail freight (the output). The indicator will therefore provide the amount of aid for one unit of additional transport volume achieved during the evaluation period (e.g. per tkm). Where data is available, some studies have also considered the extent to which there is a reduction in weight transported via the less-desirable mode achieved by a certain amount of subsidies (typically EUR 1 million).[46] The estimate can be then compared to a "hurdle rate" set while determining the objectives of a scheme, where the *hurdle rate* is the *minimum required rate of return* on an investment. In this context, it is the minimum amount of weight transported via the less-desirable mode that the scheme is designed to shift to rail.[47]

Efficiency of a scheme for reduction of external costs can also be measured in terms of avoided external costs. Such a scheme in Austria was considered effective from a cost perspective, since €1 spent under the scheme allowed avoiding an average of €3.41 of external costs during 2013-2015 and €3.39 during 2016.[48]

Some schemes have also introduced quantified funding objectives to ensure cost effectiveness of the schemes prior to the implementation of the scheme (ex-ante basis). For

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[40] For example, a project from 2018 can be attributed to displacement effects in the following 5 years for a scheme that is in effect between 2015 – 2020.

[41] TRAFFIX. "Innovationsförderprogramm Kombinierter Güterverkehr (IKV) (2015-2020), Evaluierung". Wien, 16. November 2020.

[42] State aid SA.43008 (2015/N) – Germany. One-year prolongation and budget increase of the existing aid scheme 'Guidelines on Funding for Transshipment Facilities for Combined Transport of Non-federal Companies', see: https://ec.europa.eu/competition/state_aid/cases/260975/260975_1718819_39_2.pdf

[43] However, to draw a reasonable comparison between the two metrics, data sources must be consistent. In particular, overall transported volumes must cover all aid recipients. See Section 5.2.

[44] State Aid SA.55025 – Italy Prolongation of Rail Freight Transport scheme 2020-2022, see: https://ec.europa.eu/competition/state_aid/cases1/201949/281608_2115254_110_2.pdf.

[45] https://ec.europa.eu/competition/state_aid/modernisation/state_aid_evaluation_methodology_en.pdf.

[46] State Aid SA.46720 – Germany - Guidelines on the construction, extension and reactivation of private railway sidings, see: https://ec.europa.eu/competition/state_aid/cases/266640/266640_1856227_75_2.pdf

[47] For example, during the renewal of a German scheme (SA.35363, SA.46720, SA.58570), the authorities stated the scheme had shifted a traffic volume of 117.8 million tons from road to rail, which corresponds to 75,907 *truck trips saved* for each *million euros of subsidy*, well above the hurdle rate of 31,000 *truck trips per million euros of subsidy* set for the scheme. This suggests the scheme was both cost effective and effective in promoting modal shift.

[48] See recital 20 of 'SA.48390 Austria - Prolongation of aid scheme for transport of goods by rail in certain combined transport services for 2018-2022'. Available at https://ec.europa.eu/competition/state_aid/cases/269839/269839_1971628_105_5.pdf.

instance, the German scheme (SA.46341) highlighted that the economic benefit of the aid must be at least four times the volume of the funding in the first 10 years. This appears roughly in line with cost savings projected by another State aid measure for intermodal terminals introduced in Slovakia, which projected cost savings of up to thirteen times the total investment over 30 years (SA.34369).[49]

The evaluation studies are often limited to the discussion of the scheme' effects and details on the extent of a scheme's success, rather than scheme design features. We provide more details on design features in Section 4.

[49] See recital 61 of 'State aid SA.34369 – Slovakia Construction and operation of public intermodal transport Terminals'. Available at https://ec.europa.eu/competition/state_aid/cases/247486/247486_1397824_16_2.pdf.

2. Rail infrastructure

2.1 Introduction and problem definition

The adequacy of the existing railway infrastructure is essential to ensure that the current level of potential demand can be satisfied. Indeed, if there is evidence that the railway infrastructure is inadequate (e.g., because of lack of service facilities) this may cause bottlenecks, and would be an indication that more investment in the development of the railway infrastructure might be needed. In the following, an assessment of the adequacy of the network of service facilities and the basic services they provide (Section 2.3), intermodal terminals (Section 2.4) and private railway sidings (Section 2.5) is presented. These Sections address, respectively, study question 23[50], study question 24[51] and study questions 25-26[52] of the technical specifications. Section 2.2 discusses the methodologies and information sources used for each of these analyses. Section 2.6 goes through State aid measures adopted in the past to support the development of the rail infrastructure; Section 2.6 discusses the policy conclusions that can be drawn from all of the above.

Throughout this Section, the term "railway infrastructure" refers to the ensemble of service facilities, intermodal terminals, private sidings and national railway networks. The national railway networks comprise each MS's railway tracks; taken together, these national networks make up the European railway network. In the following, the term "railway infrastructure" will be used to refer exclusively to the combination of both railway networks and service facilities, either at a national or European level. In this sense, its definition within the Section is broader than the one provided in Annex I of EU Directive 2012/34, which does not include service facilities and intermodal terminals. Finally, the public financing of rail infrastructure within the meaning of Annex I of EU Directive 2012/34 does *usually* not qualify as State aid, as it predominantly concerns the financing of natural monopolies.[53]

2.2 Methodology, data sources and limitations

As a general approach, the Consortium has collected information to provide an overview of the existing railway infrastructure and, where possible, to compute a synthetic descriptive indicator of their adequacy. Analyses are based on publicly available information, but their reliability is checked comparing it to information collected through other sources, such as responses to the survey sent to relevant stakeholders, evidence gathered through tailored interviews and desk research.

In particular, in Section 2.3 the adequacy of service facilities is assessed through an analysis of publicly available information, which covers EU27; an additional analysis is included only for Bulgaria, France, and Ireland, the three countries with (according to the available public data) the lowest density of service facilities. We check whether the insights that can be drawn from these analyses are consistent with evidence gathered through consultation of target groups via the survey and tailored interviews.

It should be noted that heterogenous definitions of service facilities limit comparability of the analyses based on public information across MS, as the Directive 2012/34/EU does not provide a technical definition of the facilities listed in Annex II. Therefore, the

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[50] "Is there evidence of a lack in service facilities described in point 2 of Annex II to EU Directive 2012/34, including freight terminals, marshalling yards and train formation facilities, including shunting facilities, storage sidings, maintenance facilities, technical facilities such as cleaning and washing facilities, refuelling facilities? The analysis should cover the density, the individual and aggregated capacity, the obsolescence and any other dimension deemed relevant and duly justified by the contractor".

[51] "Is there evidence of a lack in intermodal terminals?".

[52] Please note that, as per the Inception Report, the Consortium and the Commission agreed upon the following formulation of study questions 25 and 26: "*What is the cost and the business case for the construction of private railway sidings? The Contractor should identify the factors that drive the need for public aid*".

[53] See in that regard the so-called Analytical Grid published by the Commission in 2017, which sets out the conditions under which the public financing of rail, metro and local transport infrastructure should qualify as State aid or not (https://competition-policy.ec.europa.eu/system/files/2021-04/notion_of_aid_grid_rail_metro_en.pdf).

specific definition of certain facilities, such as freight terminals, may be different across the various institutional stakeholders, as shown in Table 4.

Table 4: Definition of freight terminals according to different sources

Definition	Source
Freight terminal means a place equipped for the transshipment and storage of intermodal transport units, where at least one of the modes of transport is rail.	Article 2 (e) for regulation (EU) 2015/1100 on the reporting obligations of the Member States in the framework of rail market monitoring
Freight terminal means a structure equipped for transshipment between at least two transport modes or between two different rail systems, and for temporary storage of freight, such as ports, inland ports, airports and rail-road terminals.	Article 3 (s) of regulation (EU) No 1315/2013 on Union guidelines for the development of the trans-European transport network and repealing Decision No 661/2010/EU
Freight terminals are “Installations where services of loading, unloading and transshipment of goods from and to freight trains or wagons are supplied. (Freight terminals are represented in the portal as 4 sub types: Intermodal terminal, Multifunctional rail terminal, Public siding, Private siding)”	User Manual of Common Portal for Rail Service Facilities
Freight terminals are “facilities in rail freight transport which are specifically built for intermodal transport (container, swap bodies, semitrailer)”.	IRG-Rail (2020)

Source: The Consortium.

The Consortium has tried to reconcile the different definitions (more information on this reconciliation is provided in Annex 13). Nonetheless, this was not possible for some of the facilities (i.e., storage sidings, marshalling yards and freight terminals). As ensuring a common definition of freight terminals was not possible, the Consortium considers data on intermodal terminals to be a reliable proxy for the availability of freight terminals in the EU. [54]

In Section 2.4, the Consortium provides evidence to assess the adequacy of intermodal terminals based on:

- publicly available information, covering EU27[55];
- collection of qualitative evidence through consultation of target group via survey and tailored interviews;
- collection of qualitative data via case studies, and in particular interviews with members of the management team of intermodal terminals in Italy, Czech Republic, the Netherlands, Hungary, Germany and Luxemburg.

Section 2.5 discusses the factors that influence the costs and benefits of building a railway siding, as informed by the existing literature and by the consultation of a relevant stakeholder with experience in providing consulting services to firms interested in building sidings. The evidence collected in this way can be applied to all MS, and informs two different analysis: an empirical one, aimed at understanding the drivers that influence the presence of private sidings in regions of Austria, Czech Republic, France, Italy and Spain, and a more theoretical framework aimed at understanding the need for State aid to incentivise the development of new private sidings.

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[54] Freight terminals encompass intermodal terminals. As information on the number of intermodal terminals was available from multiple sources (such as the Independent Regulators Group’s reports, network statements and the website Rail Facilities Portal), it was possible to triangulate the information to reach a more robust estimate of the number of intermodal terminals available in different countries.

[55] With the exception of Austria, Belgium, and Luxemburg, for which data on intermodal transport is not available, Latvia, where there is no intermodal terminal, and Malta and Cyprus, where there is no railway network.

2.3 Service facilities and access to basic services

Annex II of Directive 2012/34/EU lists the service facilities, i.e. those facilities to which access shall be granted to RU "under equitable, non-discriminatory and transparent conditions" (Art. 10, Directive 2012/34). Such facilities are:

- passenger stations, their buildings and other facilities;
- freight terminals;
- marshalling yards and train formation facilities, including shunting facilities;
- storage sidings;
- maintenance facilities;
- other technical facilities, including cleaning and washing facilities;
- maritime and inland port facilities linked to rail activities;
- relief facilities; and
- refuelling facilities.[56]

Among others, these facilities allow the provision of basic services such as parking of locomotives and wagons and fuelling services, loading and unloading, reception and dispatch, storage, customs clearance, maintenance and weighing. Depending on the train type and other factors, the "production system" requires different types and quantities of these basic services. For instance, single-wagon operations are more reliant on fuelling services as they pick up and deliver wagons from/to private sidings that are generally less likely to be electrified. Block trains and intermodal transport shuttles, on the other hand, tend to operate on electrified corridors.

Sufficient supply of these basic services is key to increase the modal share of rail freight. Availability and access to basic services is a pre-requisite for the provision of rail freight services. If these services are not available or cannot be accessed, the end product, i.e. rail freight transport, cannot be provided. Hence, bottlenecks in the provision of basic services could impede the growth of the modal share of rail. Such bottlenecks may exist because:

- such services may be unprofitable and hence not provided by the market. This manifests itself in a lack of *availability* of those services;
- incumbents or local (service facilities) monopolists might try to exclude competitors or earn supra-competitive margins. In that case, *access* to those services is restricted.

If one wanted to design policies that aim at increasing the modal share of rail, it would be important to know whether such bottlenecks in the supply of basic services exist. We start with reviewing the structure of suppliers of basic services across countries based on the replies provided in the stakeholder consultation. Then we assess the *availability* of services in two ways. First, we relate the number of facilities to the national network sizes and derive measures of density; the general results of this analysis have been also confirmed by representatives from the Community of European Railway and Infrastructure Companies (CER)[57] and by a representative of Europe's Rail Joint Undertaking (EU JU), the latter referring in particular to the number of freight terminals and marshalling yards.

For countries with sparse service facilities, we also analyse the potential demand for rail freight transport to understand whether supply or demand is the plausible driver of scarcity. Second, we rely on responses to the stakeholder consultation to investigate availability of basic services (which can better account for other dimensions that the density measure cannot consider, such as capacity). As regards *access* to basic services, we rely on the survey responses from the consultation and on insights provided by the Alliance of Passenger Rail New Entrants in Europe (ALLRAIL)[58].

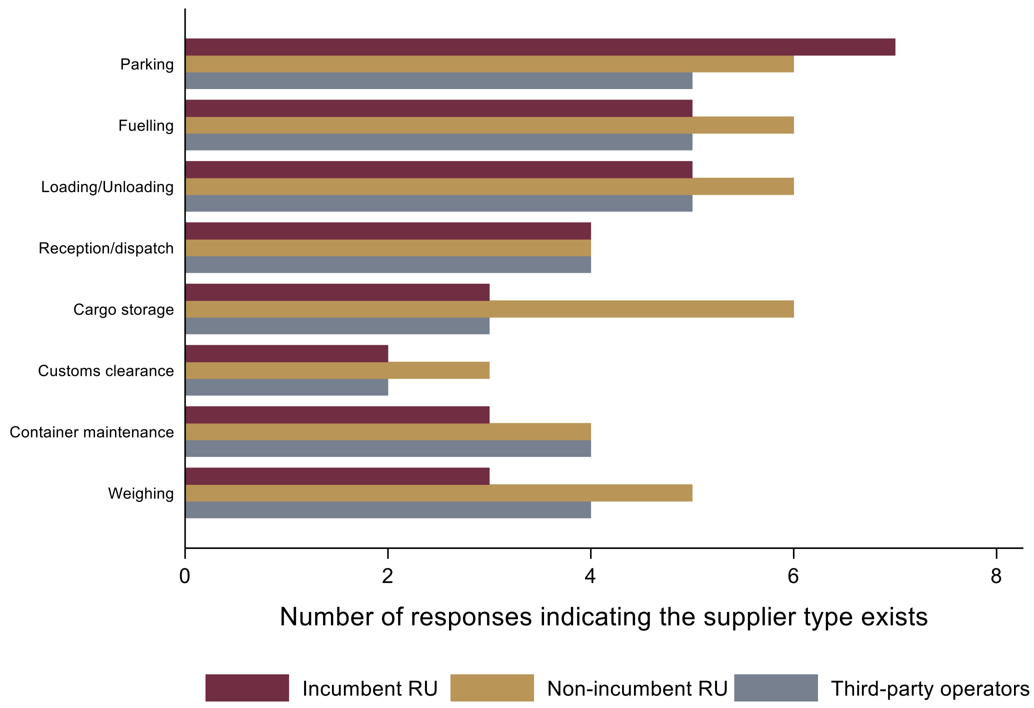
[56] For the description of the facilities, see Annex 13.
[57] CER is a European umbrella association representing national rail incumbents and infrastructure managers.
[58] ALLRAIL is a European umbrella association representing rail passenger transport entrants.

RU can either provide basic services internally (i.e. integrate vertically) or source them externally. For example, a railway undertaking offering intermodal transport could also own and manage an intermodal terminal, check-in first mile containers, temporarily store them at their facility and load them onto the train before conducting the main rail leg. On the other hand, such basic services can also be sourced from third parties, such as other railway undertakings, infrastructure managers or third-party market participants.

Consequently, the stakeholder survey inquired about the supply structure of basic services, i.e. which kind of market participants are active in the market. The survey distinguishes between three groups of basic services: *services in regard to rolling stock* (parking of locomotives and wagons and fuelling services), *services in regard to cargo* (loading and unloading, reception and dispatch, storage and customs clearance) and *other services,* including container maintenance and weighing.[59]

Figure 9 displays the supplier structure of basic services. Figure 10 illustrates the national market shares of incumbents in the respective services. Both exhibits are based on the survey responses from market regulators.[60]

Figure 9: Suppliers of basic services



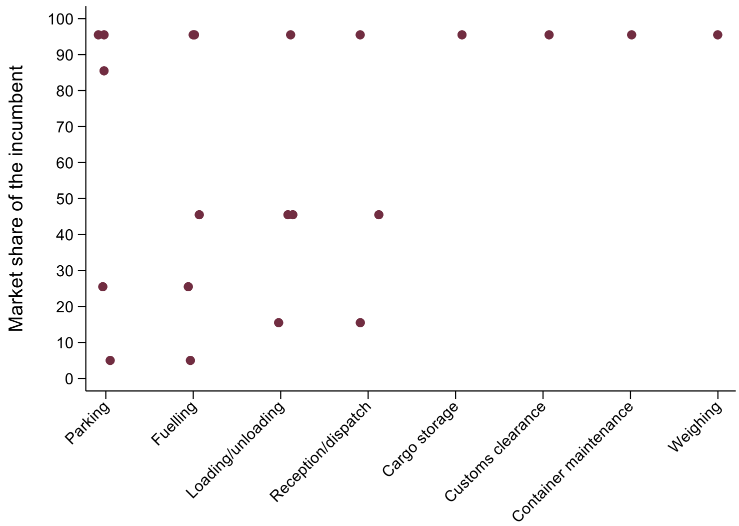
Source: The Consortium based on survey responses of market regulators. The x-axis displays the number of responses indicating that at least one supplier of the supplier type exists in the MS.

[59] Please note that some of the previously listed facilities, e.g. passenger stations, are not essential for freight transport. On the other hand, some of the listed basic services are not covered by the list of essential facilities outlined in Annex II of Directive 2012/34/EU. Furthermore, we do not consider marshalling and shunting activities as well as local and regional distribution services in this section. Rather, we assess them in Section 3.

[60] We received responses from market regulators of these countries: Austria, Czech Republic, Italy, Poland, Spain, Sweden and two other respondents that asked to remain confidential. The results should be interpreted with caution for at least two reasons. First, the data size is small. Second, regulators are usually in charge of regulating and monitoring basic services. Therefore, the responses might be biased. The responses from other stakeholders were too few to report them quantitatively in a meaningful way. To the extent possible, we enhance the insights from regulators qualitatively with survey responses from other stakeholders.

Generally, basic services are provided by all three types of suppliers: incumbents, non-incumbent RU and third-party operators. While there is a number of independent providers, Figure 10 unveils that the market shares in basic services are skewed towards the incumbent, as viewed by some market regulators. Moreover, several MS reported that some of the basic services are not present in their railway networks at all.

Figure 10: National Market Share of Incumbents



Source: The Consortium based on survey responses of market regulators. The dots represent the average of the range of incumbent's market shares per service as indicated in the reply to the survey by the national regulator.

To ensure that rail traffic can be served without causing any delay, the *availability* of facilities offering these basic services needs to be ensured. A lack of service facilities would lead to a sub-optimal offer of basic services, and thus to delays and higher costs, hindering the modal shift.[61,62]

Before assessing the current status of service facilities in Europe, given the relevance of marshalling yards for rail freight transport, the paragraphs below briefly describe the different types of yards existing in Europe, and provide a depiction of the distribution of said yards across MS.

Marshalling yards are train formation facilities, in which wagons get sorted into different tracks (usually corresponding to specific destinations) and coupled to form complete trains. Three types of Marshalling yards can be distinguished, based on the way in which wagons get sorted:

- flat yards: here wagons are sorted by shunting locomotives, which are a type of tractive rolling stock used appositely for shunting purposes;
- gravity yards: in these yards the natural difference in the ground level between arrival and departure tracks is exploited. Trains on the arrival tracks are divided into wagons, which then go down to the departure tracks thanks to the force of gravity. Sorting tracks are used to direct the wagons into the correct departure track;

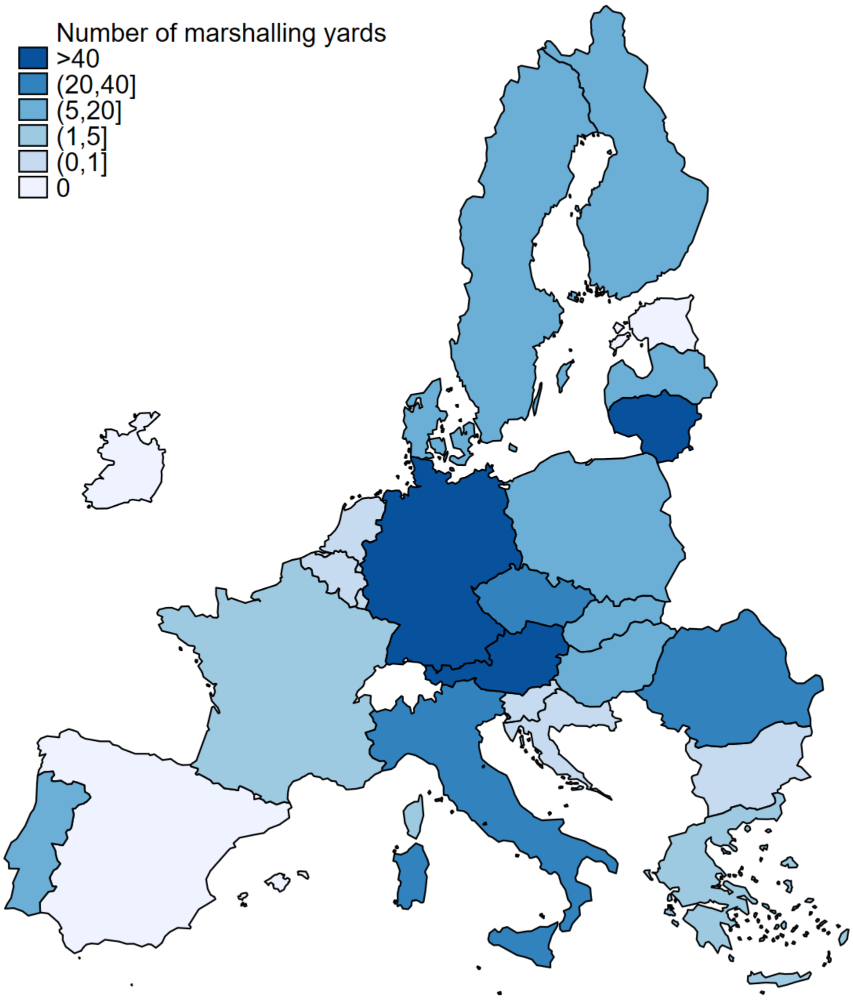
[61] A similar issue could arise if service facilities in some countries are obsolete, to the extent that more modern facilities would be able to handle higher level of traffic. Nonetheless, evidence on the obsolescence of service facilities has emerged neither from tailored interviews nor from the responses to the surveys sent to relevant stakeholder.

[62] The stakeholders' survey included a question that asked to evaluate the offer for each service facilities in the EU countries that were part of the survey sample, on a scale of 1 to 5, were 1 means "severely insufficient" and 5 "perfectly adequate". A following question asked to evaluate the effect of the COVID-19 outbreak. No answers to these questions have been received.

- hump yards: they work very similarly to gravity yards, but here the difference in the ground level is created through the building of artificial humps. They are usually equipped with track brakes to control the speed of the wagons and avoid damaging the rolling stock.

Figure 11 below depicts the number of marshalling yards per country. Before interpreting the results, it should be noted that in certain countries (e.g., Austria, France) marshalling services can be provided also in areas which are not classified as marshalling yards (e.g., sidings or intermodal terminals), therefore the figure presented below is bound to underrepresent the number of facilities in which the service is actually offered.

Figure 11: Number of marshalling yards per country



Source: The Consortium, based on the 7th8th RMMS and national Network Statements (see Annex 13)

The Consortium has also analysed the national Network Statements of the following MS (see Annex 13 for more information) to gather information on the types of marshalling yards available: Austria, Czech Republic, Denmark, Finland, France, Germany, Italy, Luxembourg, Netherlands, Poland, Portugal, Romania, Spain, and Sweden. Information on which types of marshalling yards are available in the country was available only for:

- France: Network Statements report 4 hump/gravity yards, and 1 undisclosed type of yard within an intermodal terminal;
- Germany: no precise information on the number is given, but the Network Statement mentions all three types of yards;
- Netherlands: Network Statements report 1 hump yard;
- Poland: the annex to the Network Statement reports humps being present in all the marshalling yard;

- Sweden: both flat and hump/gravity yards are present, but no precise information on the number is provided.

Other national Network Statements did not provide information on the type of yards available. Sometimes the information seemed to be available only through online portals, to which the Consortium had no access.

We will now first assess availability looking at a measure of density of service facilities. It is common in the railway literature to assess the density by looking at the ratio between the number of facilities in a country and the railway network length (see, *inter alia*, Guglielminetti et al., 2017, and Schwendinger, 2021), or the ratio between the network length and the number of facilities (see European Commission, 2021); the latter is simply the inverse of the first, but has a more direct interpretation, as it represents the average distance between facilities, and is thus preferred.

Table 5 reports the average distance between service facilities and intermodal terminals for EU27 MS, along with a synthetic index based on all the service facilities except freight terminals and passenger stations.[63] The index is meant to provide a synthetic indication of the distance between freight-related facilities in the MS; for each facility, a normalised distance between 0 and 1 is computed for each country,[64] then the average across the selected facilities is computed for each country. Only this last indicator is reported in the table. This allows to have a single indicator which can summarize the sparseness of the service facilities within each MS.[65]

Given the differences in the definition of facilities across MS, and although the Consortium has done its best to ensure the reliability of the data (see Annex 13 for more details), conclusions on the availability or lack of service facilities should not be based exclusively on this elaboration.

Table 5: Average distance in kms between service facilities, per country

Country	Passenger stations	Freight terminals	Intermodal terminals	Marshalling yards[66]	Maintenance facilities	Maritime and inland ports	Refuelling facilities	Average normalised distance
Austria	4	310	275	51	134	1238	138	0.13
Belgium	6	77	74	3602	78	30	300	0.16
Bulgaria	14	403	4030	4030	115	288	224	0.39
Croatia	5	434	174	2605	521	200	163	0.22
Czech	4	553	523	336	143	2352	162	0.25
Denmark	6	630	229	140	157	315	126	0.06
Estonia	10	25	148					0.02
Finland	11	5925	312	329	395	329	180	0.13
France	9	152	613	5519	138	2509	373	0.48

[63] Since passenger stations are not involved in freight transport, and the figures on freight terminals are not reliable, for the computation of the index these two types of facilities have been excluded.

[64] For each combination of facility-country, the normalised distance is computed as $Normalized\ distance = \frac{ObservedDistance - MinDistance}{MaxDistance - MinDistance}$, where the observed distance is the distance reported in Table 5 for a specific country, whereas the minimum and maximum distance are the distances observed for each type of facility in all the countries.

[65] As many countries in Europe are land-locked, the indicator has also been computed excluding ports (see Table 66 in Annex 14). The qualitative results of the analysis do not change based on this.

[66] The very high average distance of marshalling yards in Belgium, Bulgaria, France, and Netherlands is due to the low number of facilities in these countries (respectively 1, 1, 5, and 1). This is probably due to a change in the definition of facilities over the years, as France went from 505 marshalling yards in the 5th RMMS report of 2016 to just 5 in the 6th and 7th report.

Germany	6	98	194	595	104	260	94	0.05
Greece	7	25	327	458	191	573	208	0.11
Hungary	5	323	337	388	267	969	221	0.16
Ireland	14	292	292		1023	682		0.44
Italy	7	83	171	559	104	730	1398	0.29
Latvia	14	0		109	109	233	207	0.05
Lithuania	15	956	956	26	147		319	0.12
Luxembou	4	275	138	275	275	275	275	0.10
Netherlan	8	44	107	3220	268	87	215	0.18
Poland	7	45	431	976	85	1030	927	0.26
Portugal	5	141	1273	212	150	255	231	0.12
Romania	16	468	538	326	105	82	283	0.07
Slovakia	4	140	363	259	140	1814	107	0.18
Slovenia	4	9	242	1209	101	1209	134	0.16
Spain	11	171	397	418	636	589	722	0.29
Sweden	5	191	404	839	280	303		0.14
Eu 27[67]	7	103	281	405	156	226	179	

Note: The Consortium, based on multiple sources (see Annex 13).

Based on the data above, Bulgaria, France, and Ireland are the three countries with the overall lowest density of facilities,[68] all being characterised by an average normalised distance index of 0.39 or more. Representatives from CER, while not in the position to comment on the status of service facilities in specific MS, have confirmed that there is a lack of service facilities in Europe. In particular, CER considers that, due to low returns to the investment, there is a lack of funding for service facilities, from both public and private investors.

While a high average distance between service facilities points to a lack of connectivity of the rail transport system in comparison to the extension of the network and can provide a preliminary indication of the adequacy of the offer of the selected service facilities, the results need to be interpreted cautiously; indeed, while sparse service facilities might indicate a lack of supply, it might also reflect a low level of demand for these services. To investigate whether the lack of demand or of supply is the more plausible cause for sparse service facilities, we analyse the evolution of freight transport via inland solutions, in terms of tkm, for goods in the agriculture, mining, manufacturing, and transport sectors,[69] over the period 2009-2019. These sectors, identified by Guglielminetti et al. (2017), are considered traditional customers for freight rail transport, mostly relying on single wagonload,[70] which is highly dependent on the adequacy of the service facilities (particularly on freight terminals, marshalling yards, and private sidings, see Sections 4.1 and 4.2.3 for further information on single wagonload transport). The objective is to understand how the changes in volumes moved via rail compare to the changes in the overall volumes moved via inland solutions (i.e. the potential demand, given by the sum of the tkm moved across commodities and inland transport modes). Where potential demand declines but overall volumes moved via rail

[67] Malta and Cyprus have no railways.
[68] The qualitative results do not change if one considers the countries' area rather than length of network, as reported in Table 70.
[69] The selected categories of goods are: products of agriculture, hunting, and forestry; fish and other fishing products; Coal and lignite; crude petroleum and natural gas; Chemicals, chemical products, and man-made fibers; rubber and plastic products; nuclear fuel; Basic metals; fabricated et al products, except machinery and equipment; Transport equipment; Secondary raw materials; municipal wastes and other wastes.
[70] The Single wagonload are consignment of goods using rail solutions different from full trains (single or group of wagons) while keeping the same composition from the origin to the destination.

increase, for instance, this could indicate that the scarcity of service facilities is supply-driven. On the other hand, if we observe a decrease in the potential demand and an increase in the volumes moved via road, this might signal that demand for rail transport solutions is insufficient to incentivise investment in service facilities.

Table 67 in Annex 14 reports the time evolution of the volumes moved via different inland solutions, as well as the total volumes moved, whereas Figure 12 depicts the evolution of volumes moved via inland modalities in Bulgaria, France, and Ireland – the countries where the situation seems to be most concerning.

Figure 12: Evolution of volumes moved via road, rail and IWW, millions of tkm, road (left), and rail and IWW (right), 2009 - 2019

Source: The Consortium, based on Eurostat, variables 'rail_go_grpgood', 'road_go_ta_tg' and 'iww_go_atygo', selected goods.

France and Bulgaria present a somewhat similar trend, characterised by a reduction in the total volumes moved via inland solutions (although the reduction observed in France over the ten years period is less marked). Nonetheless, France is also characterised by an increase in the volumes moved via road and a decrease in the volumes moved via rail and inland waterway (particularly since 2014), whereas Bulgaria is characterised by a decrease in the volumes moved via road, and an increase in the volumes moved via rail and inland waterways. This points towards different possible explanations for the lack of service facilities: in a situation of a general decline in the potential demand for freight transport, France is characterised by a further reduction of rail and IWW transport, whereas Bulgaria is characterised by an increase in these two modal solutions, indicating that in France the lack of service facilities identified through the analysis of public available data could be demand-driven, whereas in Bulgaria it could be supply-driven.

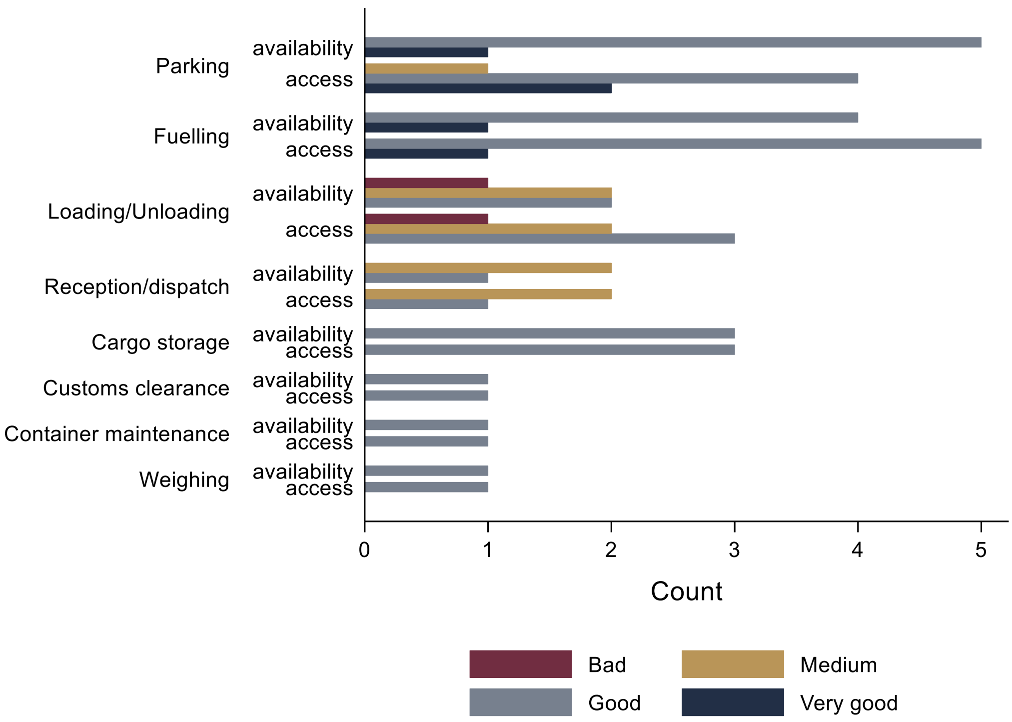
Ireland has been characterised by an increase in the total potential demand; while this has been mostly driven by volumes moved by road, also for IWW and rail, an increase can be observed. Considering that Ireland is one of the countries with the lowest density of the railway network (less than 3kms of tracks every 100 km^2 of area), the scarcity of service facilities could be demand-driven rather than supply-driven. Indeed, the increasing volumes moved via road is a clear indication that potential demand exists.

The reduction of volumes moved via rail observed in France might also start a negative feedback loop: as volumes diminish, non-profitable service facilities might be closed by IM and private service providers, leading shipping companies to shift even more freight towards road transport modes. Service facilities operators would then have to sustain an offer characterised by a relatively rigid cost structure and decreasing revenues (or sub-optimal revenue growth), leading to a further reduction in the offer of service facilities. Indeed, Guglielminetti et al., 2017 found that IM tend to avoid unexploited capacities by reducing the number of service facilities as soon as they perceive a decline in the associated traffic streams.[71]

While the analyses above were driven by the availability of service facilities in terms of density, it could not capture other dimensions such as availability and access to the basic services they provide. Indeed, availability of basic services can better account for measures of capacity that the density figures presented in Table 5 cannot consider.

Lack of availability and access to basic services can be a bottleneck for the increase in the modal share of rail. To tackle the issue, the stakeholders' survey asked the stakeholders about their perceptions of the availability and access to basic services. Figure 13 illustrates the results from the survey of market regulators.

Figure 13: Availability and access to basic cargo services



Source: The Consortium based on survey responses of market regulators.

[71] This result is based on surveys addressing Railway undertakings (RU) and Infrastructure Managers (IM) in 11 European countries (Austria, Belgium, Czech Republic, France, Germany, Italy, Poland, Romania, Sweden, Switzerland and the United Kingdom).

The responses suggest that the market regulators were – by and large – satisfied with the way basic services are provided. In their view, the availability of services and the access to existing services are mostly not a source of concern. Nonetheless, representatives from ALLRAIL have highlighted that there is a lack of independent service facilities (i.e. facilities not managed by the IM), and although access to the services provided by these facilities should be ensured by Directive 2012/34, many factors that affect access (such as capacity of the facility and efficiency of services offered) are difficult to control for national authorities, thus providing incumbents with the ability to discriminate against other market participants. We will now look in greater detail at the individual basic services by combining insights from the figures and enhancing them with isolated survey responses from RU and IM.

Generally, *parking* and *fuelling* services are provided by all three types of providers. However, incumbents in some countries enjoy quasi-monopolistic market shares. Figure 13 suggests that market regulators consider availability and access to both services to be generally good. Interestingly, the responses from some RU contradict this picture. Three out of four RU decry availability and access to *parking* as bad or insufficient. This seems alarming in light of the fact that parking is generally deemed an important basic service. RU disagree about the importance of *fuelling*. For both services, prices are often regarded as somewhat excessive.

As regards *loading and unloading* and *reception and dispatch* of goods, different types of providers exist across countries. Most respondents indicate medium or good availability and access levels. Moreover, the market share of the incumbent is below 50% in most countries. A salient outlier is the Czech market regulator, which reports bad service levels of *loading and unloading*. Interestingly, it is also the only respondent indicating that prices and access of the service are unregulated. RU tend to source both services externally. Two RU indicate that *loading and unloading* is overpriced, whereas one IM suggests that the provision of the service is too low to be profitable. On the other hand, three RU deem the price level of *reception and dispatch* reasonable. Only one RU reports bad availability and access levels.

The provision of *cargo storage* is generally perceived as adequate from all stakeholders. Just a single RU indicates that availability and access are bad and that the price level is somewhat overpriced. Generally, RU tend to purchase cargo storage services externally.

As regards *customs clearance*, it seems to be a service with a lower number of providers, irrespective of the supplier type. However, its provision is listed in Annex II of Directive 2012/34/EU and is only relevant for cross-border services. Furthermore, not a single RU indicates that availability and access are an issue. Some organize customs clearance internally. Others procure it externally.

Providers of *maintenance of containers and other loading units* and *weighing* are manifold, although Figure 10 indicates a high market share of at least one incumbent. RU consistently assign medium to very high importance to *loading unit maintenance*. Lower importance is given to *weighting*. Both services are typically procured externally for three out of four respondents. No respondent finds major issues with availability and access for either service. Only one points out that *weighing* is very overpriced. On the other hand, one IM indicates that the price level of *loading unit maintenance* is too low to be profitable.

CONCLUSIONS:

There is evidence of lack of service facilities in EU MS, although whether this scarcity is likely supply- or demand-driven would require a case-by-case analysis. CER claims that the lack is possibly driven by insufficient funding due to low returns associated with the investment.

Availability and access to basic services offered, *inter alia,* within these facilities are considered by Market Regulators (MR) to be generally good, although it has emerged that there could be a lack of independent facilities, as incumbents are the main providers of basic services.

2.4 Intermodal terminal

Intermodal terminals can be defined as "service facilities for the transshipment of standardised loading units (containers, swap bodies, semi-trailers), where at least one of the modes served must be rail or inland waterway" (UIRR and UIC, 2020). This definition might differ from the definition used in other parts of the study, where intermodal terminals can also cover short-sea/road or aviation/road combinations.

For the purpose of this support study, the Consortium has conducted six case studies on the following intermodal terminals:

1) Bettembourg Intermodal Terminal (Continental);[72]
2) METRANS Hub in Prague (Continental);[73]
3) Port of Duisburg Intermodal Terminal (Inland);[74]
4) Mahart Container Centre (Inland);[75]
5) Rotterdam World Gateway (Maritime);[76] and
6) Trieste Marine Terminal (Maritime).[77]

The terminals object of the case studies are some of the largest intermodal terminals in Europe; the Metrans Hub In Prague covers 420,000 m^2 of area, whereas Mahart Container Centre covers 110,000 m^2. Moreover, there terminals handle very high volumes of freight each year: Bettembourg Intermodal Terminal handled 200,000 transshipment in 2018, and Trieste Marina Terminal handled around the same number of transshipment in 2019. Thus, results based on the case studies cannot necessarily be extended to other intermodal terminals.

From the case studies, it has emerged that these intermodal terminals are largely profitable, and their main source of revenues is the handling (i.e. loading and unloading) of containers. Indeed, while most terminals provide also accessory services, these are complementary to the main line of business, and are offered mostly because these are necessary to ensure that containers can be transhipped (e.g., custom clearance, weighing, or maintenance). According to information provided by METRANS and Trieste Marine Terminal, the prices for the handling of the containers are published and fixed; moreover, BASF (a multinational chemical company, which is a user of intermodal terminals, but also owns and manages intermodal terminals) has explained that while these prices are indeed fixed, the actual cost for the transshipment is determined by the number of movements: for instance, if a containers has to be unloaded onto the ground, the loaded onto a truck to be transported to the rail terminal within the intermodal terminal, and then loaded onto the rail freight wagon, this would count as three different movements. Moreover, the cargo often needs to be stored in the terminal for some time, which also affects the final price charged to shippers; while usually a number of days are considered in the initial price charged, the longer the cargo has to be stored in the terminal, the higher the final price.

Terminals have different cost structures; differences seem to be mostly driven by the technologies and level of automation (of transshipment and other services) implemented in each terminal. Indeed, for Trieste Marine Terminal and Bettembourg Intermodal Terminal, which are less automated than other terminals analysed in the case studies, personnel costs represent a higher share of total costs. These costs can be considered for the most part to be fixed costs, and for Trieste Marine Terminal they represents around 50% of the annual costs, while 40% of the total costs stem from space and infrastructure investments; fuel and electric energy needed to operate the cranes and the vehicles within the terminal represent just about 10% of the total costs, and are the only costs that can be considered variable, making the cost structure of Trieste Marine Terminal quite rigid. On the contrary for more automated terminals, such

[72] See Annex 15.
[73] See Annex 16.
[74] See Annex 17.
[75] See Annex 18.
[76] See Annex 20.
[77] See Annex 19.

as METRANS and Rotterdam World Gateway, fuel and energy represent the higher share, thus making their cost structure more flexible.[78] Indeed, at the METRANS Hub in Prague most operations are automated, and only some requiring specialised personnel are still performed by the terminal's staff (e.g., the sealing of the container); similarly, at Rotterdam World Gateway most operations are automated, in particular the transshipment of containers from deep-sea vessels, and only the operations at the train terminal are not. For a more automated terminal such as METRANS, fuel and energy represent around one third of the total costs incurred for operations, while investments and personnel expenses represent the remaining two thirds. More information on the costs related to different transshipment technologies are provided in DG Move (2022). Finally, the level of automation seems to affect also the terminals' ability to operate at maximum capacity. Less automated terminals, such as Trieste Marine Terminal seem to need to keep a buffer of spare capacity to deal with unexpected situations and avoid congestion.

More information on the case studies is provides in Annex 15 to Annex 20.

Intermodal terminals are necessary to ensure that the flow of freight moved through different modes is possible. Indeed, the lack of sufficient terminal capacity – where capacity can be interpreted both as the capacity of the single terminal or the presence of enough terminals on the territory – will lead to delays in the transport of goods, as the terminals would be overloaded and not in a position to timely process all the freight that transits through the terminal, or will make it impossible or uneconomical to use intermodal services if no suitable terminal exists at reasonable distance.

The lack of terminals' capacity has been highlighted during a workshop of the United Nations Economic and Social Council, which was attended, *inter alia*, by MS representatives, intergovernmental organisations as well as non-governmental sector organisations; one of the challenges to intermodal transport discussed was the lack of intermodal freight terminal capacity.[79] Similarly, Jagelčák et al. (2017) and Pyza and Jachimowski (2018) indicate that the insufficient terminals' capacity in Slovakia and Poland is problematic for the development of intermodal freight transport.

Kramarz et al. (2021) analyse the relationship between the number of intermodal terminals (serving rail) and the reliability of rail freight transport in Poland. The study computes a *Load Index* (LI), defined as:

$$LI_i = \frac{Intermodal\ rail\ transport\ [million\ tonnes]}{number\ of\ intermodal\ terminals}.$$

It should be noted that while the LI can provide the first insight into the adequacy of the intermodal network, it cannot control for terminals' capacity nor for the type of intermodal units that each terminal can handle, which means that results should be interpreted with caution. The authors find a strong relationship between the overloading of intermodal terminals, as proxied by a high value of the LI, and disruption of freight transport, such as the cancellation or delay of freight trains. The adequacy of intermodal terminals is thus assessed by computing the LI for all EU27 MS for which data is available, as reported in Table 6. More precisely, based on the results of Kramarz et al. (2021), a LI above 0.35 (the mean value found for Poland over the period 2012-2018)[80] indicates that intermodal terminals in the country may be overloaded.[81]

[78] Rotterdam World Gateway is a peculiar case, as it is a very new terminal and therefore it is still amortising the investments made in in transshipment technologies, which makes its cost structure relatively rigid right now, but is expected to become more flexible in the future.

[79] See Economic and Social Council "Report of the working party on intermodal transport And logistics at its forty-seventh session", available here.

[80] Kramarz et al. (2021) is based on quarterly data. Thus, the mean value found in the paper (0.088) has been multiplied by 4 to obtain the value of 0.35.

[81] Kramarz et al. (2021), through a regression analysis, finds that the relationship between the LI and the number of disruptions of rail freight activities (time of delays and number of trains cancelled) is statistically significant. As the hyperplane defined by the OLS estimator passes through the mean of the dependent and independent variables, the mean of the LI has been chosen as a threshold.

Table 6 reports the LI for the EU27.[82] Many MS seem to have an insufficient number of intermodal terminals (i.e., a LI above 0.35) given their level of intermodal rail transport. A certain degree of heterogeneity can be observed in whether it is the high amount of freight moved or the low number of intermodal terminals that act as the main driver of the LI. For instance, Slovenia and Hungary have very similar freight traffic, but the former has only 5 terminals, compared to the 23 terminals in the latter; moreover, according to the data available from the portal "www.intermodal-terminals.eu", terminals in Hungary are, on average, 18% larger and can arguably also process more freight.[83] The two countries with the higher level of freight moved, Italy and Germany, also present different levels of terminal overload, with Germany having more than double the intermodal terminals but only around 50% more intermodal traffic in terms of tonnes moved.

Table 6: Load index of intermodal rail terminals per country

Country	Number of intermodal terminals with rail connections	Intermodal rail volume (millions of tonnes)	Load Index
Portugal	2	5.07	2.53
Slovenia	5	5.32	1.06
Czech Republic	18	13.26	0.74
Lithuania	2	1.41	0.71
Italy	98	60.55	0.62
Netherlands	30	18.53	0.62
Bulgaria	1	0.54	0.54
Slovakia	10	4.90	0.49
France	45	21.42	0.48
Germany	203	92.20	0.45
Poland	43	19.34	0.45
Sweden	27	10.71	0.40
Spain	40	13.02	0.33
Denmark	11	3.49	0.32
Hungary	23	5.28	0.23
Greece	7	0.69	0.10
Estonia	7	0.64	0.09
Croatia	15	1.31	0.09
Romania	40	2.11	0.05
Finland	19	0.87	0.05
Ireland	7	0.16	0.02

Source: The Consortium, based on Eurostat rail_go_contwgt and multiple sources (see Annex 13). Note: To avoid that the influence of the COVID-19 outbreak might bias the results, the data on intermodal rail transport refers to 2019. Intermodal traffic comprises national, international and transit volumes. Values in red indicate a LI higher than 0.35.

[82] Austria, Belgium, and Luxemburg are excluded as data on intermodal transport is not available, while Latvia is excluded because it has no intermodal terminals. Finally, Malta and Cyprus have no railway networks. Eurostat - Data Explorer (europa.eu).

[83] Intermodal-terminals.eu is an online interactive database of intermodal terminals, managed by Kombi-Consult. Unlike Railfacilitiesportal.eu, it does not cover only rail-connected intermodal terminals. Nonetheless, only a fraction of the total intermodal terminals present in the EU is covered by the database. Data available for Slovenia covers 5 terminals, with a total area of 429,250m2; data available for Hungary covers only 6 terminals with a total area of 608,500m2.

The results of the literature review and of the stakeholder survey, presented below, are broadly in line with the results of the analysis based on the LI. Indeed, in around 60% of the countries analysed with the LI, intermodal terminals are overloaded, in line with the results of a survey conducted by UIC (2020), in which 56% of the respondents highlighted a lack of terminal capacity as a bottleneck for intermodal transport, and with the results of Jagelčák et al. (2017), and Pyza and Jachimowski (2018) for Slovakia and Poland respectively.

The results of the survey also point toward a lack of capacity for intermodal terminals. Table 7 below reports the information collected by the Consortium through the stakeholder survey. The Consortium received 10 relevant replies: 1 from the Lithuanian IM, 5 replies from MR (Austria, Czechia, Germany, Lithuania and Poland) and 4 RU (Germany, Lithuania, Poland, and Slovakia).

Table 7: Stakeholders' assessment of investment needs in terminals

Type of Investment	Needed to achieve break-even for a loss-making terminal	Needed to double amount of transported goods by 2050	Importance
Increase in number of terminals	n/a	Yes (LT, PL/MR, PL/RU, AT/MR)	Indispensable (LT/IM, LT/RU, AT/MR, PL/RU) High (LT/MR) Moderate (PL/MR)
Increase in capacity of existing terminals	Yes (LT, CZ/MR, DE/RU, PL/RU)	Yes (LT, PL/MR, PL/RU, AT/MR)	Indispensable (LT/IM, LT/RU, AT/MR, PL/RU) High (LT/MR, PL/MR)
Longer loading tracks	Yes (LT, PL/RU)	n/a	n/a
Larger cranes	Yes (LT, PL/RU)	n/a	n/a
Additional space of storage and sidings	Yes (LT, DE/RU, PL/RU)	n/a	n/a
Longer train lenghts limits	Yes (CZ/MR)	n/a	n/a
Modernisation	Yes (LT, PL/RU)	Yes (LT, AT/MR, PL/RU)	Indispensable (LT/IM) High (LT/MR, LT/RU, PL/RU) Moderate (AT/MR)
Standardisation	Yes (LT, PL/RU)	n/a	n/a
Others	Capacity of border crossing (PL/RU)	Increase of share of rail transport in servicing intermodal termianls (PL/MR)	Indispensable (PL/MR)
Existing investment programmes	Yes (CZ/MR, SK/RU, DE/RU, LT/RU) No (PL/RU) AT/MR: Investment program that started in January 2022 (aims at increasing capacity and renewal of terminals and sidings: https://www.schig.com/anschlussbahn-und-terminalfoerderung) DE/MR: Government promoting construction and expansion of combined transport facilities since 1998. Current government plans to promote creanability of semi-trailers and exempt the route from/to combined transport terminal up to a max of 50 km from the truck tall		

	IT/MR: National Recovery Resilience Plan (PNRR) LT/MR: National Transport Development Programme 2014-2022. LT/IM: Merged investment: Connecting Europe Facility (CEF), LTG, Ministry of Transport and Communication, CEF and Ministry of Finance investment to Dual Use Military Mobility in Kaunas, European Gauge Rail Line (Rail Baltica). PL/MR: CEF for Transport, Recovery and Resilience Facility (in preparation), The European Funds Program for Infrastructure, Climate and Environment (in preparation).

Source: The Consortium, based on stakeholder consultation

To double the amount of transported goods by 2050, Lithuanian stakeholders consider that the number of terminals should increase by at least 50% (possibly up to 200%) and the capacity of existing terminals by at least 100%. Two RU also indicate that the number of terminals and their capacity should increase throughout Europe; the Austrian MR also considers that the increase of both capacity and number of intermodal terminals is essential to double the amount of transported goods by 2050. Moreover, the Lithuanian IM explains that the number and the capacity of terminals should have already been increased, but they cannot develop existing terminals as fast as necessary because of limited funding or limited space. A representative from the International Union of Wagon Keepers (UIP),[84] interviewed for this study, has also stated that loading facilities (i.e., freight terminals and intermodal terminals) are inadequate within the EU because of severe capacity constraints. A similar point was raised by representatives from CER, who stated that investment in transshipment facilities in European ports would be needed.

Moreover, two inland waterway operators have indicated a lack of intermodal terminals in the Czech Republic and Sweden (both having a LI above 0.35, though Sweden is close to the threshold, indicating that the lack of intermodal terminals might not be limited to those providing IWW services).[85]

More generally, the responses indicate that an increase in capacity would also be needed to ensure that loss-making terminals could reach the break-even point. Nonetheless, there exists a trade-off between consolidating the volumes that are handled by a terminal, to ensure that it reaches the break-even point, and other policy targets, such as the reduction of CO_2 emissions; indeed, consolidating volumes towards these terminals could hinder the development of a more dense network of terminals, which could allow to reduce the length of the road leg in intermodal transport and also promote the shift to rail due to shorter distances between departure/arrival nodes and intermodal terminals. While smaller terminals belonging to a denser network could sometimes be loss-making, and thus need support to remain in business, these could allow to reduce the negative externalities caused by road haulage. If one wanted to promote intermodal transport, this trade-off should be considered.

The results of the case studies paint a relatively different picture to what has been described so far. Indeed, the management of the METRANS Hub in Prague, the Trieste Marine Terminal and the Rotterdam World Gateway Terminal (see Annex 16, Annex 19, and Annex 20, respectively) have pointed out that the existing capacity (both at their terminals and in other intermodal terminals in Europe) is more than sufficient to handle both the current level of freight traffic and a possible growth; this is also the view of the Czech Market Regulator which has indicated that all intermodal terminals are private companies and assumes that they are developing and operating in a profitable way. On the contrary, the managers of the different intermodal terminals interviewed for the case studies have argued that a bottleneck exists at the level of the existing railway network. According to them, not only is the current network unable to support longer and heavier trains (the maximum length in the EU is currently 750m, whereas, in the

[84] UIP is a European umbrella association, representing more than 250 wagon keepers and entities in charge of maintenance.

[85] A third operator has stated that intermodal terminals are also lacking in Austria, but due to lack of data on intermodal transport a LI is not available for the country.

U.S., it is 1.5km), which would be instrumental in reducing the costs of freight transport and promoting a modal shift but it is also congested and unable to handle any growth in freight traffic. Representatives from the European Rail Freight Association (ERFA),[86] ALLRAIL, and the Community of European Railway and Infrastructure (CER)[87], and BASF, interviewed for this study, have also claimed that the railway network is congested and investments are deemed necessary to expand the railway network (although the representative from BASF has claimed that, in the short run, one should consider the possibility of relying on different routes for passenger and freight transport, to reduce the effect of the congestion); the representative from ERFA has also specified that congestion mainly affects the electrified part of the railway network, as this handles most of the freight traffic.

While the evidence that national railway networks are congested seem to be persuasive, having been confirmed by multiple sources with different incentives, this does not disprove the finding that there is a lack of intermodal terminals, both in terms of numbers and capacity. Indeed, even if the managers of the intermodal terminals that have been analysed for the case studies claim that their specific terminals are able to handle an increase in demand (or can expand to accommodate it), it should be considered that constraints can exist at regional level or for specific combinations of intermodal freight transport modalities (e.g., IWW and road).

CONCLUSIONS:

Intermodal terminals in the EU seem overloaded and scarce in number. This finding is supported by both the analysis of public available data, the stakeholder survey, and the existing literature. While the intermodal terminals analysed for the case studies generally operate at a profit, and managers have claimed that if there was excess demand that could not be served more terminals would be opened, the situation can be heterogeneous across regions and type of intermodal terminals. Moreover, intermodal terminals managers, as well as representative from umbrella associations, have highlighted that the main bottleneck to intermodal transport is the congestion of national railway networks. While there is enough evidence to consider that the national railway networks are actually congested, it is likely that both issues coexist and therefore that there is still a scarcity of intermodal terminals in Europe.

2.5 Private railway sidings

Private sidings are privately-owned rail tracks that connect loading points (e.g., industrial plants or warehouses) to the main railway network, allowing companies not to rely on road transport for the first and/or last mile. Regardless of the type of freight moved, in theory, the use of private sidings could offer considerable benefits to companies in terms of larger capacity, greater flexibility, and improved reliability; by allowing the goods to be moved directly between the national railway network and the companies' premises, companies may also be less exposed to certain issues that may disrupt their logistic chains (e.g., driver shortages or roads congestion). Indeed, most of the rail freight transport in Europe transits on private sidings (PWC et al., 2016); for instance, almost 85% of transport volumes in Germany (Steer, 2015), around 60% in Austria,[88] and 70% in Slovakia (Abramović et al., 2014). Sidings can thus be pivotal in promoting the modal shift to rail and reducing the CO2 emissions connected to freight transport.[89]

Section 2.5.1 describes the different factors that affect the cost of building a siding and the status of private sidings in selected European regions and analyses which factors affect the presence of sidings in said regions. Section 2.5.2 proposes an analysis to estimate the aid intensity that would be needed to incentivise the construction of new sidings.

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[86] ERFA is a European umbrella association representing rail freight transport entrants.
[87] CER is a European umbrella association, representing IM and national incumbents.
[88] See Anschlussbahnen - WKO.at.
[89] According to the European Environment Agency, rail freight transport causes 15.6gCO2/tonne-km, whereas road transport causes an average of 139.8gCO2/tonne-kilometre. Source: European Environmental Agency. Available online: https://www.eea.europa.eu/data-and-maps/daviz/specific-co2-emissions-per-tonne-2#tab-chart_1 (accessed on April 12, 2022).

2.5.1 Private sidings in Europe

Despite the benefits that private sidings can provide, road transport solutions are usually cheaper in the short term (and possibly in the long-term, unless a certain threshold of freight moved can be reached) and, therefore, often preferred by companies which have to choose between building a new siding or relying or road haulage. Indeed, while road connections are already available and, for the most part, paid for by the public sector, companies have to bear most – if not all – of the costs associated with constructing a private siding (Schwendinger, 2021), and these are not negligible. Indeed, an expert from ERFA Gleisanschluss,[90] who has been interviewed for the study, has confirmed that before building a siding, private companies need to conduct a feasibility study to identify where the siding can be connected with the main railway network and the way to connect with the network without interfering with the traffic, connecting the node to the factory or plant premise of the company; moreover, these choices are influenced by the need to select the shortest connection that can ensure that the topographic characteristics of the territory do not lead to increases in the construction costs; for instance, the presence of steep gradients, forest lands or waterways can increase the civil engineering costs. Similarly, dense pockets of urban development that need to be avoided, or the need to cross highways, will also lead to higher investments for the siding construction. Moreover, private companies also need to cover the costs related to the operation and maintenance of the private siding and the related equipment, such as signalling and safety systems.

Generally speaking, sidings are an investment with a long expected technical useful life (around 30 years, according to a response to the stakeholders' survey). Nonetheless, the economic useful life can be curtailed because of the risk that in the future, the siding might not be served anymore. This could happen for two reasons: on the one hand, sidings rely on the provision of SW transport from RU, which is usually not profitable and is losing its share (see Section 4.2.3); on the other hand, the part of the railway network to which their siding is connected might be discontinued. At the time of the investment the probabilities of these occurrences are not known, which might lead companies to consider shorter useful life when evaluating the business case for building a siding. On the contrary, road transport exposes firms to no such risks (Schwendinger, 2021; Guglieminetti et al., 2017; ERFA Gleisanschluss's expert). Thus, private companies may perceive building and maintaining a siding as a non-priority investment and decide to rely on road haulage to save on costs and guarantee the dependability of their logistic chain in the future.[91]

The expert from ERFA Gleisanschluss has also highlighted that the decision to build a siding will be highly dependent on the type of freight that needs to be moved and on the scheduling of the journeys. The need to move time-sensitive goods or sporadic consignments are both situations in which a firm would likely rely on road haulage rather than invest in a siding.

Perhaps also as a result of the above, there seems to be a general decline in the number of private sidings around Europe: in Germany, the number of sidings went from about 13,000 in 1993 to 1,300 in 2013; in Austria, there were 521 active sidings in 2020, whereas in 2010 there were 840; in Italy, the number of sidings declined from 405 in 2013 to 384 in 2021. Moreover, according to the World Bank, the number of private sidings in Europe is expected to decline further over the next few years.[92] This might cause a modal shift toward road transport (despite an observed increase in rail freight

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[90] ERFA Gleisanschluss represents more than 40 industrial and logistic companies in Germany that own private sidings, and offers consultancy services to firms that intend to build one.

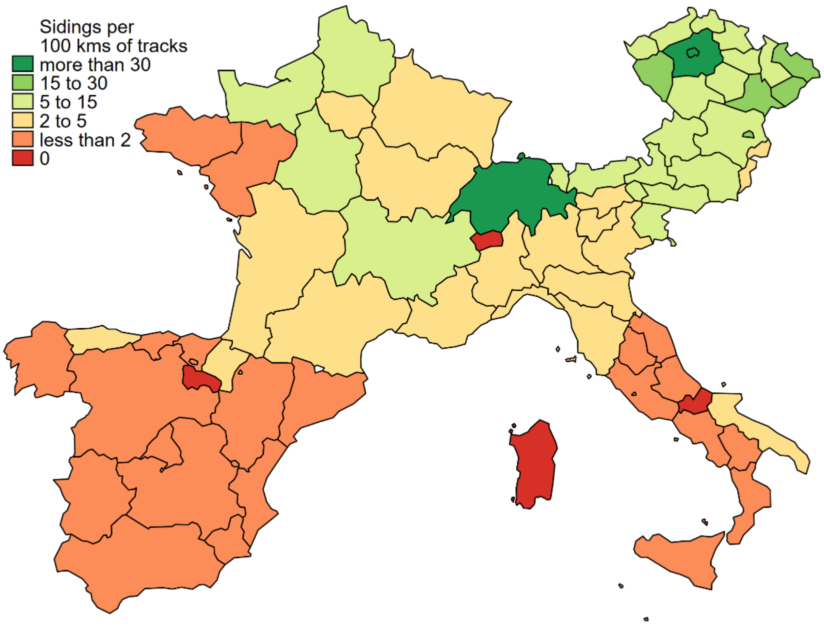
[91] See VDV's Private Siding Charter, available on their website.

[92] The World Bank (2020), project appraisal document on a proposed loan in the amount of €314.5 million (us$350 million equivalent) to the republic of turkey for a rail logistics improvement project. Available online: https://documents1.worldbank.org/curated/en/223371593828212937/pdf/Turkey-Rail-Logistics-Improvement-Project.pdf (accessed on April 13, 2022).

traffic of about 4.1% between 2015 and 2018, road freight transport increased by approximately 21% during the same period, according to ERA, 2020).

Figure 14 below depicts the current number of private sidings for every 100km of railway network length in a selection of EU countries for which regional information on the number of private sidings is available and compares it with Switzerland, which may serve as a role model having the largest density of private sidings in Europe, with more than 35 private sidings per 100 km of rail network length (46 private sidings). It should be noted that in Switzerland, the law. n. 742.41[93] provides for a contribution of up to 60% of the costs related to the construction of private sidings, which can be increased to 80% for projects of national importance (§8.2, law n. 742.41). This may have contributed significantly to the number of private sidings observed therein.

Figure 14: Private siding density in selected EU countries (sidings/100 km network length)



Source: The Consortium, based on data from various sources: National Network Statements (Italy, Spain, France, Czech Republic, Austrian Chamber of Commerce).

In the regions being analysed, a high degree of heterogeneity in the number of sidings can be observed, even within the same country. The Czech Republic shows the highest density of private sidings, having between 15 and 35 in the Moravia, Prague, and Liberec regions. Austria follows closely, and the number of sidings is more homogeneous, with a density between 5 and 15 for every region with the exception of Vienna (15-35 private sidings per 100 km) and of Burgenland (1-5 private sidings per 100 km). In the southern and western regions, France generally has a higher density of private sidings than Italy and Spain, although a high degree of heterogeneity can still be observed.

A regression analysis[94] has been carried out on cross-sectional data of the number of sidings per region in Austria, Czech Republic, France, Italy, and Spain (the same countries depicted in Figure 14, for which regional data on the number of sidings was available), to understand how the different factors highlighted above influence the costs and opportunities related to the construction of a siding and could explain the heterogeneity observed in the number of private sidings. In short, the main elements that influence the decision to build a siding are: (i) the amount of freight moved; (ii) the type of freight moved; and (iii) the costs related to the siding construction. Six explanatory variables

[93] Available on Fedlex in French, German and Italian.
[94] See Annex 10 for an explanation of the simple linear regression model.

have been identified to control for these three elements: the number of manufacturing companies in the region, to proxy for the level of economic development of the region (note that using GDP would bias the results for regions for which the tertiary sector drives the GDP); the economic specialisation of the region;[95] the regional railway network length, to consider the influence of the (average) distance that needs to be covered by the siding to reach the closest connecting rail nodes; and the standard deviation of the elevation of the region, to take into account topographical characteristics that would require higher investments in civil engineering. The standard deviation has been preferred to average elevation because, even with a high average elevation, the terrain could be relatively smooth, whereas the standard deviation better captures heterogeneity in the region's elevation level, which is what drives cost the most.

The results of the regression are presented in Table 8. The estimated coefficients allow to understand how each variable influences the number of sidings per region

Table 8: Regression analysis of sidings

Variables	Coefficient	Standard error
Network length	0.000154***	(0.000020)
Std of elevation	-0.001994***	(0.000101)
# Manufacturing companies	0.000011***	(0.000001)
Region specialised in production of metals	-1.576468***	(0.302791)
Region specialised in mining activities	-0.446717***	(0.048949)
Region specialised in production of transport vehicles	-0.529846***	(0.130423)
Constant	4.313499***	(0.047340)
N. Obs	64	
R-squared	0.31	

*Source: The Consortium based on desk research and Eurostat "sbs_r_nuts06_r2". Standard error in parenthesis. * 90% confidence level; ** 95% confidence level; *** 99% confidence level. Note: for reasons of data availability, the 14 administrative units of the Czech Republic have been grouped into the standard 8 regions, according to the NUTS2 definition.*

The regression results provide some insights into the drivers of sidings per region. On the one hand, the results confirm what has been discussed above: a widespread railway network is positively related to the number of sidings per region, as it makes it relatively easier to find nearby connecting rail nodes, thus reducing the average length of the siding and, therefore, construction costs. On the other hand, a higher standard deviation of the elevation is negatively related to the number of sidings because a more rugged terrain leads to higher costs and therefore disincentivises the investment in the siding. Finally, the number of manufacturing firms is positively related to the number of private sidings, confirming that regions with higher production levels also show a higher number of sidings.

[95] These are dummy variables taking values 0 or 1. Each region is classified as being specialised in either production of metals, chemicals, transport vehicles or mining activities based on the number of firms active in the sector; the sector with the highest number of firms identifies the specialisation of the region (with the related dummy variable being equal to 1, and the others to 0). These sectors have been identified by Guglielminetti et al. (2017) as those which rely the most on single wagonload transport; given the nature of this type of transport, these are arguably also the ones most likely to rely on private sidings. A final sector, the agricultural one, is not part of the regression as data on the number of firms active in the sector is not available at the regional level.

As the number of sidings is a counting variable, the coefficients have been estimated using a Poisson regression rather than ordinary least squares, which allows to estimate the percentage change in the number of siding using the formula $percentage\ change = 100 * (e^{\beta} - 1)$. For very small β, such as the one related to GDP, this can be approximated as $100 * \beta$. The estimated coefficients for the specialisation of the region show that everything else equal, regions specialised in the production of chemicals have more private sidings; indeed, regions specialised in the production of metals, in mining activities or in transport vehicles have respectively 79%, 36%, and 41% fewer sidings that regions specialised in the production of chemicals.

2.5.2 Business case for the construction of a private siding

Considering the decline in the number of private sidings that has been observed in the selected European countries, as well as the further reduction expected in the future, State aid might be needed if one wanted to incentivise the development of new sidings.

In this section, the Consortium relies on a model to compute and compare the equivalent annual cost (EAC) of building a private siding and of relying on road haulage (see Annex 10 on how to compute the EAC). The EAC methodology is a way to compute the cost-per-year of an investment over its expected useful life; through the computation of an annuity factor, the methodology allows to compare the annual costs of two different projects transforming them into annual expenditures. The starting point of the EAC analysis is the definition of a baseline scenario. In this scenario, the different variables that influence the final cost of building and operating a private siding have been assigned a specific fixed value. This first analysis is followed by a sensitivity analysis in which the values assigned to the different variables are changed one at a time, to understand the relative importance of each factor, *ceteris paribus*. This allows to compare these costs from the point of view of a private firm.

Indeed, while rail transport, on long distances, is cheaper than road transport, the required high initial investment might deter firms from building a siding. The analysis of the EAC allows to estimate the magnitude of the subsidy that would be needed for a private firm to be indifferent between:

- building a private siding and then operating it to move its freight to the nearest connection to the main railway line; or
- rely on road haulage to move its freight to the nearest intermodal terminal, where the cargo will be transshipped onto rail transport.

In our analysis, it is assumed that the nearest intermodal terminal for the second option is quite close to the location where the siding would be built (the distance is considered to be just 10% longer than the length of the siding). Indeed, the distance used for the road transport is not a "road leg", which would be quite longer and likely increase the viability of the private siding.

As the cost of moving the freight to its final destination on rail once the national network has been reached is common to both alternatives, this part of the cost of rail freight transport can be ignored. When comparing the two alternatives, it is possible to estimate the amount of aid, expressed as a percentage of construction costs, that will make the firm indifferent between building and operating a siding or resort to road transport.

For the baseline scenario of the analysis, the column "Value" of Table 9 below reports the value assigned to each specific variable. The table also reports the definition of each variable, as well as the source for the value assigned in the baseline scenario.[96]

[96] These variables are directly related to the ones discussed in Section 2.5.1; for instance, a more rugged terrain could increase unit construction costs, whereas a higher number of manufacturing companies could lead to the creation of an industrial centre, greatly increasing the volumes moved on a yearly based and thus the competitiveness of a private siding vis-à-vis road haulage.

Table 9: Variables affecting the decision to build a private siding

Variable	Definition	Value	Source
Tonnes	Annual volume of freight	52,000 tonnes	ERFA Gleisanschluss (link)
Capacity of loading units	The capacity of loading units	27.6 tonnes	DSV (link)
Annuity factor	Present value factor used to compute the EAC of the initial investment		
	Cost of capital (informs the annuity factor)	2.24%	World Bank (2020) and European Commission (link)
	The useful life of the siding (informs the annuity factor)	30 years	Stakeholders' survey
C_{rail}*	Cost of rail transport	€0.0153/tkm	See notes
C_{road}**	Cost of road transport	€0.111/tkm	Upply (see notes)
km_{road}	Length of the road leg	20% longer than the length of the siding	Assumption based on World Bank (2020)
km_{rail}	Length of the siding	3.5 km	Railway Market Analysis 2018 (link)
Maintenance	Maintenance cost	10% of the total construction costs	Assumption based on World Bank (2020)
Transshipment	Transshipment cost	€32.33/loading unit	DG Move (2022) for 40' containers transshiped with a gantry crane
Unit construction cost	Unit construction costs	€1.3M/km	Stakeholders' survey

*Source: The Consortium. *Note: Cost of rail refers to the average variable cost (€/tkm) across all countries. The average variable cost considers traction costs, track access charges and the variable proportion of labour costs across all countries. **Note: Cost of road refers to the prices of container-trucks (€/tkm) carrying 27 tonnes of cargo averaged across all countries.*

The following equations show how to compute the aid intensity (i.e., the percentage of aid that would make the private firm indifferent between building and operating a new siding or relying on road haulage) starting from the investment and operating costs of the two alternatives:

$$Tonnes * km_{rail} * C_{rail} + \frac{Unit\ construction\ costs * length\ of\ siding}{Annuity} * (1 - Aid\ intensity) + Maintenance =$$
$$Tonne * km_{Road} * C_{road} \left(\frac{Tonne}{Capacity\ of\ loading\ units}\right) * transshipment\ .$$

$$Aid\ intensity = \left(Tonne * km_{Road} * C_{road} + \left(\frac{Tonne}{Capacity}\right) * transshipment - Maintenance - Tonne * km_{rail} * C_{rail}\right) * \frac{Annuity}{Construction}$$

Based on the values defined in Table 10, the baseline scenario is characterized by a cost of capital of 2.24% and an expected useful life of 30 years. This implies that the annuity factor ($Annuity\ factor = \frac{1-\left(\frac{1}{(1+r)^t}\right)}{r}$)[97] would be equal to 21.67. Given that the siding in this scenario is 3.5km long, and the unit construction costs are €1.3M/km, the construction costs would be equal to €4.55M, requiring a yearly maintenance expenditure of €45,500.

Moving the freight via road, given the volumes of freight moved and the capacity of loading units would require the transshipment of approximately 1,884 loading units. Based on these assumptions, a subsidy would need to cover 82.4% of the construction costs of the siding, in order for a firm to be indifferent between building and operating a siding for 30 years or relying on road haulage.

Before moving on to the sensitivity analysis, the role of transshipment costs should be discussed. Indeed, transshipment costs represent an important part of the EAC that is attributed to the road transport alternative; data on transshipment costs is based on DG Move (2022) estimates for a 40' container moved using a gantry crane.[98] DG Move (2022) estimates also other transshipment costs based on different container sizes; nonetheless, the size of the container influences directly the maximum tonnes that it can contain, and therefore the variable "capacity", which in turn influences the number of truck journeys in the EAC model, which would also influence the cost of road transport, as more (less) truck journeys would imply a lower (higher) cost in terms of tkm. For this reason, the sensitivity analysis will not be carried out with respect to this variable, as it would be impossible to vary the transshipment costs keeping everything else equal.

Table 10 below presents the result of the sensitivity analysis carried out varying the unit construction costs, volumes of freight moved per year, the economic useful life of the siding and the length of the siding. Each time the value assigned to one of the variables in the model is changed, all the others are kept constant at the value identified in Table 9; for instance, in the first column, the unit construction costs vary between €750,000 and €2,000,000 per km, while keeping all the other variables at the values considered in the baseline scenario. The variables for which the results of the sensitivity analysis are reported in the table below are considered the most relevant ones; for reasons of space, the results of the sensitivity analysis carried out on the remaining variables have been reported in Table 60 in Annex 11.2.[99]

Table 10: EAC sensitivity analysis result

Unit construction costs (€/km)	Aid intensity	Freight moved per year (tonnes)	Aid intensity	Useful life	Aid intensity	Length of siding	Aid intensity
€750,000	53.7%	52,000	82.4%	3	97.7%	0.3	No aid needed
€1,000,000	70.7%	78,000	62.8%	5	96.2%	0.5	No aid needed
€1,250,000	80.9%	104,000	43.2%	10	92.8%	1	10%
€1,500,000	87.7%	130,000	23.6%	15	89.8%	2	61%
€1,750,000	92.5%	156,000	4.0%	20	87.1%	3	78%

[97] r is the cost of capital, and t is the expected useful life of the investment. See Annex 11.
[98] For more information on how the costs are computed, please see section 3.2.3 of DG Move (2022).
[99] For more information on the sources that have informed the definition of the value of the variables in the sensitivity analysis, see Annex 11.2.

€2,000,000	96.2%	182,000	No aid needed	25	84.6%	4	86%

Source: The Consortium.

From the results of the analysis, it emerges that while all variables have a strong effect on the aid intensity, the expected economic useful life is the variable with the least influence, although very short economic life would require the aid to cover almost the whole investment. While private companies might consider a very short economic life (e.g., 3 years), other factors have a much stronger influence on the business case to build a siding and therefore on the need to support the investment with aid; based on the assumptions of this framework, no aid is needed for very short sidings or when more than a certain volume is moved each year.

While the aid intensity can vary significantly based on different assumptions on the values of key variables, it should be noted that private sidings can be supported also indirectly, through subsidies to different stakeholders. For instance, developing a denser national network can reduce the cost of building a siding in two ways: (i) reducing the distance between a firm's premises and the national network, and (ii) allowing for easier connections on less rugged terrain, reducing the unit construction costs. Similarly, as freight moved on private siding relies heavily on the provision of single-wagon services by RU, aid that aims to reduce the cost of this service might also lead to lower prices charged to private sidings operators, thus increasing the price difference between road and rail haulage and reducing the EAC of the private siding.

CONCLUSIONS:

Despite the importance of private sidings for freight transport, there has been a decline in their number in Europe, which is expected to continue. Sidings require high initial investments on top of the operating costs, which might lead firms to prefer cheaper (in the short term) solutions such as road transport. The analysis carried out by the Consortium has shown how different factors affect the business case for the construction of private sidings. Subsidies are likely needed to incentivize the development of private sidings, although said subsidies can also be indirect (for instance, developing the national network density and thus reducing the length of the siding will reduce the cost of the siding).

2.6 State aid for infrastructure

State funded infrastructure support measures made up almost a third of measures identified in the State support measures database[100] (32/104 measures, 30.77% of all measures). Note that in this subsection we refer to infrastructure broadly, including and even overwhelmingly referring to infrastructure that can be duplicated, and the financing of which, in principle falls under state aid rules (see Section 2.1). In total the budget for infrastructure measures over the period was approximately €1.39 billion with a budget of €79.40 million in 2012 and €154.05 million in 2021.

Infrastructure related State support measures were identified across 10 Member States, the United Kingdom and Switzerland[101]. The number of schemes in operation across the period remained relatively consistent with 9 schemes in operation in 2012 and 11 in 2021.

In this Section we provide an overview of state support measures implemented by Member states, the United Kingdom and Switzerland between 2012-2021 and supplement this with available ex-post analysis across three broad categories: terminals, private sidings, and other measures[102]. The objective of this is to provide a commentary on available ex-post analysis on state aid measures for infrastructure. This commentary is

[100] See section 2 for an overview of this database including methodology.
[101] Namely: Austria, Croatia, Czech Republic, France, Germany, Hungary, Italy, Romania, Slovakia, and Sweden.
[102] Examples of 'other' state aid infrastructure measures include the construction of tunnels and a measure on logistics centres.

also used to draw general policy and scheme design recommendations which are discussed in Section 5 of this report.

2.6.1 Terminals

The vast majority (87.5%, 28/32) of the infrastructure support measures identified concerned the construction or improvement of rail or intermodal terminals. Of the 28 measures identified, 15 related to the construction of intermodal terminals and 18 related to the improvement of intermodal terminals[103]. These measures are discussed in the below subsections. With the exception of 4 of these measures which also allowed for the construction of private railways sidings which are discussed separately in Section 2.6.2. The final 4 state support measures categorised as *'other'* predominately concerned the construction of rail tunnels. These measures are discussed in Section 2.6.3.

In total the budget for measures related to the construction and improvement of intermodal and rail freight terminals over the period approximately €1.12 billion with budgets of €74.40 million in 2012 and €118.04 million in 2021.

2.6.1.1 State aid for the construction of intermodal and rail freight terminals

Of the 12 measures related to the construction of intermodal and rail freight terminals[104]. 5 related to individual aid (i.e., investment in a single terminal) and 7 related to schemes (i.e., state support measures which allowed for the possibility of the construction of two or more intermodal terminals).

There is little publicly available information on the individual aid measures. Two intermodal terminals: Termini Imerese Port (SA.35193), and an intermodal terminal in the Lavis industrial area (SA.28642) appear to have been constructed. However, no reports alluding to the timeliness of the terminal's construction, cost effectiveness of their construction or their effect on modal shift could be identified.

Construction of 1 terminal, namely a bulk terminal in the port of Osijek (SA.43109) is not complete, and it was not possible to determine if construction was on schedule. Equally, the Consortium could not discern if the remaining two intermodal terminals: construction of an intermodal terminal at Mohacs port (SA.41275) and an additional terminal at Umea port (SA.43724) had been completed[105].

The Consortium identified relevant '*ex-post'* evaluation on 4 of the 7 schemes. The German scheme '*guidelines on funding for transshipment facilities for combined intermodal transport: non-federal companies'* has been running since at least 2002, and was extended twice between 2012 and 2021, first in 2015 (see SA.43008)[106] and then again in 2016 (see SA.46341)[107].

Both extensions provided some evaluation: SA.43008 stated that according to a 2013 survey, 64% of the movements of goods that took place in terminals in Germany had

[103] Note that a measure can relate to both the construction and the improvement of intermodal terminals.
[104] Excluding private siding measures which are discussed in Section 4.6.2.
[105]The Consortium did locate one news article, see 'Mohács port construction put on delay Mohács port construction put on delay - BBJ**,** which stated competition of the construction of the intermodal port had been delayed from 2017 to 2019 but no evidence that construction of the port had now completed or was ongoing. Equally although the port operated by Kvarken Ports in Umea is clearly functional, it was impossible to determine if project for which state aid was granted (which was for the construction of an additional intermodal terminal) has been completed.
[106] See SA.43008 'One-year prolongation and budget increase of the existing aid scheme 'Guidelines on Funding for Transshipment Facilitates for Combined Transport of Non-federal Companies. https://ec.europa.eu/competition/state_aid/cases/260975/260975_1718819_39_2.pdf
[107] See SA.46341 'Scheme on funding transshipment facilities for combined transport of non-federal companies' https://ec.europa.eu/competition/state_aid/cases1/201921/265853_2070613_119_2.pdf

been supported under the existing scheme. On that basis, the German authorities concluded that the 135% increase to multimodal transport between 1998-2013 would not be possible without the aid.[108]

In 2015, the scheme was subject to a spending review ('*Haushaltsanalyse*'[109]) this caused the German authorities to implement several modifications to the scheme. These modifications suggest that whilst previous iterations may have been successful at causing modal shift, they may not have been cost effective, the changes included:

(i) a quantified funding objective: expand transshipment capacity in Germany overall by an average of 9,000 loading units per million euros of aid;
(ii) a lower cap on funding intensity for intermodal transport transshipment facilities located near seaports[110];
(iii) a condition that aid could no longer be granted if the overall economic benefit is expected to be lower than the funding, and that the economic benefit achieved within the first 10 years of the funding had to be at least 4 times the volume of the funding.

Although an overall economic benefit of 4 times the volume of funding may appear high, a 2013 decision on the construction and operation of public intermodal transport terminals in Slovakia (SA.35369)[111] estimated the construction of 4 new intermodal terminals[112] would generate savings in external costs of 13 times the cost of total investment, a total saving of €1,793,352,204 over 30 years. This analysis, conducted by the Slovakian authorities, considered savings on congestion, accidents, emissions, noise, and climate. This suggests an economic benefit of 4 times the volume of funding over 10 years might be feasible in some cases.

The United Kingdom has operated the freight facilities grant scheme since 1974, which facilitates the transfer of freight from road to more environmentally modes of transport, originally the scheme only covered rail freight facilities but subsequent modifications in 1981, 1983, and 1993 extended its scope to inland waterway freight facilities, and intermodal transport operators. In 2001, the scope of the scheme was further extended to cover short seas shipping freight facilities. The scheme is still operated by the Scottish and Welsh devolved governments, although the Department of Transport does not currently offer the scheme in England. It commissioned a review of revenue support freight grant schemes in 2020 which concluded that start-up costs were not a 'significant enough issue to warrant further consideration'.[113]

Although the Consortium could not identify any recent ex-post evaluation of the scheme, an academic article by Allan Woodburn (2007)[114] found the scheme to be 'largely successful and to have attracted considerable private sector investment', even if he also states that the process could be made more transparent and consistent.

The Czech scheme for upgrading and constructing combined transport terminals (see SA.39962) was recently evaluated when the State aid scheme was renewed in March

[108] See recital 11, SA.43008 'One-year prolongation and budget increase of the existing aid scheme 'Guidelines on Funding for Transshipment Facilitates for Combined Transport of Non-federal Companies. https://ec.europa.eu/competition/state_aid/cases/260975/260975_1718819_39_2.pdf.

[109] See recital 5, SA.46341 'Scheme on funding transshipment facilities for combined transport of non-federal companies' https://ec.europa.eu/competition/state_aid/cases1/201921/265853_2070613_119_2.pdf

[110] Aid was capped at 15 euros per loading unit for terminals near seaports, lower than the 33-euro cap for loading unit for other terminals (which was already in place).

[111] See SA.35369 Slovakia – Construction and operation of public intermodal transport terminals. https://ec.europa.eu/competition/state_aid/cases/247486/247486_1397824_16_2.pdf. Note that this decision does raise some concerns on the necessity of the aid, although these concerns do not relate to the analysis stated above.

[112] Namely: Pálenisko tri-modal terminal (Bratislava), Hlohovec (Leapoldov), Teplička (Žilina) and Bočiar (Košice).

[113] See page 114 of ARUP 2020, 'review of revenue support freight grant schemes: final report', available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/864460/review-revenue-support-freight-grant-schemes.pdf.

[114] Woodburn, A., 2007. '*Evaluation of Rail Freight Facilities Grant Funding in Britain*'. Transp. Rev. 27, 311–326. https://doi.org/10.1080/01441640600990418 .

2022 (see SA.100031)[115]. Although the evaluation did not state specifically if new terminals had been constructed it did state that the previous iteration of the scheme only utilised roughly a third of its budget of €93,000,000 due to both to administrative delays (pre COVID-19 pandemic) and the COVID-19 pandemic, the new scheme has been introduced on the same terms as the old scheme. The Czech authorities remain confident that transport operators and terminal operators will be interested in using the new scheme.[116]

The French Atlantic railway project (SA.38714) intended to construct a link two new intermodal terminals (one in Aquitaine, Bayonne, and the other in Nord-Pas-de-Calais, Lille). The project was abandoned in 2017 with the court of auditors stating the project generated losses of approximately €69,300,000[117].

Although the court of auditors cites several reasons for the project's failure which included concerns from the environmental authority relating to the projects risk of noise pollution and vibrations, and 'a very reserved opinion' of the general commission of investment regarding the project's socio-economic benefit, they conclude that the project was ultimately axed due to strong opposition within the province of Tarnos due to the nuisance of regular crossing of the city by 850-metre-long rail convoys.[118]

CONCLUSIONS:

No relevant 'ex-post' evaluation on individual State aid decisions for terminals was identified. 'ex-post' evaluation for four out of seven (57.14%) State support schemes were identified.

- Evaluation was mostly positive: two of the schemes (2/4, 50%) appear to have had significant positive effect on modal shift, one of the other schemes had a mixed effect, as it utilised a third of its budget and experienced significant administrative delays (1/4, 25%), the other scheme was a failure as it was cancelled at a loss of over 60 million euros, (1/4, 25%).
- One scheme offers an evaluation of cost effectiveness, this was negative.

2.6.1.2 State aid for the development of rail freight and intermodal terminals

The Consortium identified 18 measures related to the development of terminals:[119] 9 instances of individual aid and 9 schemes. As with the measures detailed in Section 2.6.1.1, there is little publicly available information on the individual aid decisions, it was not possible to discern if any of the 9 terminals which benefited from individual aid conducted their developments in a timely or cost-effective manner, or the impact of the developments on modal shift.

[115] For initial decision see SA.39962 https://ec.europa.eu/competition/state_aid/cases/255511/255511_1685635_116_2.pdf , renewed by SA.100031 https://ec.europa.eu/competition/state_aid/cases1/202214/SA_100031_107A6F7F-0100-CB43-BAC5-89D995B46895_41_1.pdf.

[116] See recital 16, SA10031 The Czech Republic – Reintroduction of the aid scheme for upgrading and constructing combined transport terminals. Available at https://ec.europa.eu/competition/state_aid/cases1/202214/SA_100031_107A6F7F-0100-CB43-BAC5-89D995B46895_41_1.pdf.

[117] Court Of Auditors, 2017 'Rail motorways: an ambition that is struggling to achieve' See Le rapport public annuel 2017 Tome II : l'organisation, les missions, le suivi des recommandations (ccomptes.fr) [French]

[118] Court Of Auditors, 2017 'Rail motorways: an ambition that is struggling to achieve' See Le rapport public annuel 2017 Tome II : l'organisation, les missions, le suivi des recommandations (ccomptes.fr) [French].

[119] 6 of these measures also allowed for the construction of intermodal terminals and thus any relevant analysis has been included in section 3.6.1.1. 3 measuresincluded relevant analysis are: 'Aid scheme for the modernisation and construction of combined terminals (Czech Republic), See SA.39962, available at https://ec.europa.eu/competition/state_aid/cases/255511/255511_1685635_116_2.pdf. Guidelines on funding for transshipment facilities for combined transport (Germany), See SA.43008, https://ec.europa.eu/competition/state_aid/cases/260975/260975_1718819_39_2.pdf. See SA.50217 https://ec.europa.eu/competition/state_aid/cases/275541/275541_2025774_144_2.pdf. The Freight Facilities Grant Scheme (UK), see https://ec.europa.eu/competition/state_aid/cases/246647/246647_1413321_61_2.pdf.

However, ex post evaluation was identified for 5 (5 out of 9, 55.56%) of the schemes. 3 of the schemes also allowed for the construction of terminals thus any relevant analysis is included in Section 2.6.1.1, it was possible to locate evaluation on 2 of the remaining schemes.

France has two schemes for the development of inland waterways: one for the modernisation and innovation aid plan for the river fleet (PAMI) (SA.35139, SA.48804 and SA.57398) and an aid plan for modal shift towards inland waterway transport (PARM) (SA.35575 and SA.48332), although both these schemes predominately appear to focus on rolling stock, they also included provisions for the purchase of quayside handling equipment and terminal expansion. Although, it was not possible to locate analysis specifically related to terminal development, evidence from the State aid decisions suggests that at least the PAMI scheme was successful in attracting applications, as in SA.57398[120] the total budget for PAMI needed to be increased due to an increase in the number of worksites and work at existing sites intensifying, an increase in the urgency of rolling stock upgrades due to an aging fleet, and local authorities launching extensive training schemes.

SA.47779[121] concerns the renewal of an Italian scheme for the development of combined intermodal transport in the Friuli Venezia Giulia (FVG) region which aims to modernise regional infrastructure and services to improve the efficiency of freight transport service and develop combined intermodal transport across the region. As part of the renewal, the Italian authorities provided an ex-post analysis of the scheme between 2010-2015. They found that the scheme contributed to an annual increase of intermodal traffic of 11.9% in 2014, nearly double the rate of increase before the scheme started in 2009 (5.2%). The scheme was particularly effective in supporting terminal activities which accounted for approximately 40.96% of the total budget of the scheme.

CONCLUSIONS:

The Consortium couldn't identify any *'ex-post'* evaluation on individual aid decisions, but did identify relevant 'ex-post' evaluation on five out of nine (55.56%) of the schemes.

- Four of which had a positive result on modal shift (4/5, 80%) and one of which is mixed (1/5, 20%).
- One scheme appears to offer evaluation of cost effectiveness, which was negative.

2.6.2 Private sidings

Section 2.5 provided evidence that the number of private sidings in Europe has been declining. It is therefore unsurprising that the Consortium only identified four private sidings support schemes in operation between 2012-2021. Private sidings schemes support schemes have been in place in Austria (SA.34985, SA.48485[122]), Germany

[120] See SA.57398 'Increase in the overall budget of: Aid Plan for the Modernisation and Innovation of the river fleet for the period 2018-2022 (PAMI)' Available at 286154_2178572_74_2.pdf (europa.eu).

[121] SA.47779 Friuli Venezia Giulia - Interventions for the development of combined transport https://ec.europa.eu/competition/state_aid/cases/269501/269501_1931632_120_2.pdf.

[122] See SA.34985 'Intermodal Transfer Guidelines and Guidelines on the construction of private railway connections' available at https://ec.europa.eu/competition/state_aid/cases/245111/245111_1398705_116_2.pdf and SA.48485 The intermodal transfer guidelines and the guidelines on the construction of private railway connections available at https://ec.europa.eu/competition/state_aid/cases/270030/270030_1939480_90_2.pdf.

(SA.35363, SA.46720, SA.58570[123]) and Switzerland[124] since at least 2012[125]. France (SA.48483[126]) introduced a state support scheme for private sidings in 2018.

Although the four schemes had considerable budgets.[127] All the schemes also contained provisions concerning the construction or improvement of private railway terminals or loading equipment, therefore their budgets cannot solely be attributed to private sidings. Equally, maximum aid intensity for the three schemes ran in Member states was capped at 50%, meaning that construction of a new private siding often still results in a significant private investment[128]

Evaluation of the schemes was mostly positive. The German scheme (SA.35363, SA.46720, SA.58570) was last renewed in 2020, during this renewal the German authorities stated the scheme had shifted a traffic volume of 117.8 million tons from road to rail, which corresponds to 75,907 truck trips saved for each million euros of subsidy, well above the hurdle rate of 31,000 truck trips per million euros of subsidy set for the scheme. This suggests the scheme was both cost effective and effective in promoting modal shift.

Evidence provided in SA.48485[129] from the processing agency in the Austrian scheme (SCHIG mbH), stated that an additional 2.2 million tons of freight had been shifted onto rail-based modes of transport since 2012. However, they also stated that applications for new installations have been decreasing with increased demand for the support of existing projects. The lack of applications for new private sidings supports evidence on the decline of private sidings.

CONCLUSIONS:

Four State support schemes for private sidings were identified. Two schemes had publicly available 'ex-post' evaluation, these were both positive in terms of overall effect and in modal shift (2/2, 100%). No evaluation of cost effectiveness was identified.

2.6.3 Other

Asides from terminals and private sidings, the Consortium identified 4 state support measures which focused on other aspects of infrastructure. 2 of these related to the construction of rail tunnels in Switzerland[130], one related to construction of a rail tunnel between Denmark and Germany (SA.39078)[131] and one related to the construction of

[123] SA.35363 is not publicly available, See SA.46720 'Guidelines on the construction, extension and reactivation of private railway sidings' available at 266640_1856227_75_2.pdf (europa.eu) and SA.58570 'Guidelines on the construction, extension, reactivation and replacement of railway sidings and related infrastructure' https://ec.europa.eu/competition/state_aid/cases1/20212/288060_2231582_73_2.pdf.

[124] See 'Investment contributions for private freight transport facilities' for more details. Available at Federal Office of Transport FOT Investment contributions for private freight transport facilities (admin.ch) (German)

[125] some form of support has potentially existed in Switzerland since the 1980's, see Federal Office of Transport FOT Investment contributions for private freight transport facilities (admin.ch)

[126] SA.48483 'Aid scheme for connected terminal installations (ITE)' available at https://ec.europa.eu/competition/state_aid/cases/271735/271735_1966772_79_2.pdf.

[127] In 2021, the three schemes in Member states all had multi-million Euro budgets. The Intermodal Transfer Guidelines and Guidelines on the construction of private railway connections (Austria) had a 2021 budget of €10,000,000. The Aid scheme for connected terminal installations (France) had a €12,000,000 budget in 2021. The Guidelines on the construction, extension, and reactivation of private railway sidings (Germany) had a €14,000,000 budget in 2021, The Swiss Investment grants for transfer systems for combined transport and sidings scheme has a budget of 300 CHF between 2021-2024.

[128] Under the Swiss scheme up to 60% of the costs related to the construction of private sidings are eligible, which can be increased to 80% for projects of national importance. Under the Austrian scheme, 40% of the costs of construction or extension of railway sidings are eligible.

[129] See recital 20 of SA.48485 'The intermodal transfer guidelines and the guidelines on the construction of private railway connections' available at https://ec.europa.eu/competition/state_aid/cases/270030/270030_1939480_90_2.pdf.

[130] Namely NEAT (New Rail Link through the Alps) and Construction and financing of the 4-meter corridor

[131] Financing of the construction of the Fehmarn Belt fixed link, See SA.39078 for more information, the tunnel is still under construction and thus there is no ex-post evaluation. See https://ec.europa.eu/competition/state_aid/cases1/202016/280910_2147483_492_2.pdf for more information.

logistics infrastructure in Italian convergence regions (SA.34238)[132]. No *'ex-post'* evaluation of these measures was identified.

CONCLUSIONS:

Four additional State aid schemes were identified, however, there was no publicly available 'ex-post' analysis of their modal shift or cost effectiveness.

2.7 Conclusions

Section 2 has provided an in-depth analysis of the current status of the railway infrastructure, looking at service facilities and the basic services offered therein, intermodal terminals, private sidings, as well as, more broadly, the European railway network. While different levels of the infrastructure have been analysed separately, to properly assess the findings of each Section a holistic view is needed.

Indeed, the national railway networks, private sidings and the different types of facilities belong to a single system, where each part is complementary to the other. It should thus be understood that a bottleneck at a specific level of the infrastructure system can create disruptions at other levels and hinder the goal of the modal shift. Therefore, policies aimed at sustaining one part of the system may manifest their benefits also for other parts.

The starting point is necessarily the European railway network. Indeed, managers of multiple intermodal terminals interviewed for the studies, representatives of European umbrella associations, as well as a representative from BASF have claimed that the railway network is currently congested and likely not in the position to sustain the foreseeable growth. Regardless of the availability of services and other facilities, the evidence seems to suggest that support is needed to further expand the existing railway network to the level that it can support an increase in demand for railway services. According to the representative from BASF, though, while this solution could help in the long run, in the short run an alternative could be a segmentation of the railway lines, based on the type of traffic (i.e., passenger or freight).

Available evidence on service facilities has shown that there might be a sub-optimal number of facilities in some countries. Indeed, Bulgaria, France, and Ireland have, on average, the lowest density of freight-related service facilities (i.e., number of facilities every 100km of railway network). The low density in these MS indicates a lack of connectivity of the freight transport system compared to the extension of the network, which could have a negative impact on the supply of basic services, leading to delays and higher costs that ultimately hinder the modal shift. Although the results of the stakeholder surveys have indicated that availability and access to services provided by certain facilities is not problematic, the low response rate impacts the extent to which these findings can be generalised; moreover, representatives from ALLRAIL have highlighted that there is a lack of independent facilities, which could provide vertically integrated incumbents with the ability to discriminate against entrants. While evidence of potential discrimination is very limited, if this is indeed the case the primary solution would be a stronger enforcement of the existing rules. Representatives from UIP have highlighted that the number of maintenance facilities will need to grow to meet future demand.

There is also evidence of a lack of intermodal terminals across Europe, both in terms of the capacity of existing terminals and in the number of terminals available. Many MS seem to have an insufficient number of intermodal terminals relative to the demand for intermodal rail freight transport. While interviewed intermodal terminal managers (6) in different countries have reported that intermodal terminals are operating profitably, have enough capacity to address an increase in demand, and that if there was more demand that could not be met, it would be profitable to build more terminals, the extent

[132] Namely the Regional aid scheme for private transport and logistics infrastructure in Italian convergence regions https://ec.europa.eu/competition/state_aid/cases/243348/243348_1349331_52_2.pdf.

to which their claims can be extended to other geographical areas and type of intermodal terminals is limited. Indeed, there can be heterogeneity in the presence of intermodal terminals across different regions, and although a specific area (or type of terminal) might not be lacking, another could be afflicted by a low number of terminals. The fact that terminals might be lacking in specific areas is likely due to the low returns that the investment could ensure. Loss-making terminals might need support to remain in business, but allow to increase the pool of choices for shippers and the connection to the national railway network, thus reducing the negative externalities caused by road haulage and possibly allowing different parts of the networks to be used more, redirecting traffic from the congested areas. If one wanted to promote intermodal transport, the trade-off between a denser intermodal terminal network and the cost of sustaining them should be considered.

More broadly, there is enough evidence to substantiate the findings on the lack of intermodal terminals; thus, subsidies aimed at promoting the development and expansion intermodal terminals could be warranted. Indeed, despite the State aid already granted or authorised in Czech Republic, France, Germany, Hungary, and Italy, there is still evidence of lack of intermodal terminals.

Finally, evidence on private sidings has shown that there is a general decline in the number of private sidings around Europe, particularly in Germany, Austria, and Italy, and the number is expected to decrease further over the next few years. This net reduction is driven by the high number of dismissed siding combined with the low number of newly built sidings. The low number of new sidings can be explained by multiple reasons:

(i) sidings require a high initial investment. Indeed, before building a siding, private companies need to conduct a feasibility study to identify where and how the siding can be connected with the main railway network, considering also topographical characteristics of the territory that can influence the costs of the siding (for instance, the existence of steep gradients, forest lands or waterways can increase the civil engineering costs);

(ii) sidings are an investment with a long expected technical useful life (around 30 years, according to a response to the stakeholders' survey). Nonetheless, the economic useful life can be curtailed because of the risk that in the future, the siding might either not be served anymore by RU, or be connected to a part of the national railway network that has been dismissed by the IM;

(iii) road haulage could be comparatively cheaper and more reliable, especially for short distances.

The different factors that can influence the business case of building a siding are interconnected and should not be considered in isolation. Policies aimed at supporting the development of private sidings should consider all the factors driving their cost, uncertainty, and profitability with respect to road solutions; while there exist already some schemes (in Austria, France, and Germany) to promote the development of sidings, in light of the reduction observed, these have not been successful, at least not to the extent needed.

The siding itself, although important, represent only part of an interconnected rail system. As a result, while subsidies aimed at covering the funding gap are the most direct choice, different solutions can incentivize private companies to build a siding. For instance, increasing the density of the railway network could reduce the length of a siding, and thus the funding gap; providing supports for the basic services offered by service facilities would reduce the cost of rail transport, allowing to increase the competitiveness of the siding and to reduce the risk that a RU would not serve it anymore. Finally, disincentivising the use of road freight transport would also enhance the competitiveness of private sidings. Overall, direct subsidies and other policy options could potentially be combined to reduce the overall burden that has to be borne by a private firm that aims to build a siding, if one wanted to promote the construction of new private siding.

3. Rolling stock

3.1 Introduction and problem definition

There is a concern that the existing rolling stock fleet might be obsolete and in need of renewal, which may also be the result of the significant costs related to access to rolling stock and its maintenance. Section 3.3 addresses study question 18[133], providing a snapshot of the condition of existing rolling stock together with an assessment of the private sector's ability to finance its renewal, as well as the second part of study question 17[134], investigating whether rolling stock's book value can be considered a good proxy for its market value for the purpose of granting aid aimed at financing rolling stock investment.

Access to rolling stock may be complex and costly thus representing a significant barrier to entry and/or expansions in railway markets for existing or potential RU and contributing to explaining the sub-optimal condition of rolling stock. Section 3.3 describes the availability of rolling stock and the costs related to its access and maintenance, emphasizing relevant differences across market segments. Evidence providing an indication of the relevance of the costs related to access and maintenance of rolling stock for railway undertakings is also discussed in Section 3.4, with the aim of addressing the first part of study question 17.[135] The same Section also provides evidence on whether rail incumbents may have an incentive to hinder access to rolling stock or make it more costly for other market participants (study question 20[136]).

Section 3.5 addresses study questions 19[137] and 21[138], assessing the business case for the introduction of innovative and clean technologies; Section 3.6 goes through State aid measures adopted in the past to support investment in rolling stock including reduction of track access charges aimed at incentivise the migration to innovative/environmental friendly technologies (study question 22[139]); Section 3.7 discusses the potential policy conclusions that can be drawn from all of the above.

3.2 Methodology, data sources and limitations

The analysis on the condition of existing rolling stock discussed in Section 3.3 is based on publicly available information, for EU27 but only for freight wagons, and on the data on rolling stock collected from National Vehicle Registers (NVR data), for France, Germany, Italy, Poland, Slovakia, and Spain.

A data request has been sent to the Registration Entities in all the countries in the survey sample, but only France, Germany, Italy, Poland, Slovakia, and Spain have provided

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[133] "What is the average age of existing (i) rail freight rolling stock (at least per category of specialised rolling stock referred to in footnote 4) and (ii) rail passenger rolling stock (regional, high speed, regular long-distance and night train services)? Is the level of private financing sufficient to ensure a renewal (i) of the freight rolling stock fleet and (ii) of the passenger rolling stock fleet (regional, high speed, regular long-distance and night train services)?"

[134] *"What is the observable difference between book value and market value of the freight and passenger rolling stock?"*

[135] *"What is the incidence in percentage points of the cost of depreciation and of the cost of maintenance) of rolling stock (locomotives and wagons) in the cost structure of (i) rail freight transport and (ii) rail passenger transport?"*

[136] *"What is the percentage out of the total fleet of the used rolling stock owned by rail incumbents (i) that they lease or sell on the market and (ii) that they scrap? What is the average remaining life cycle and technology of the rolling stock scrapped by rail incumbents? What is the percentage out of the total scrapped rolling stock that could not be reused or retrofitted due to economic, technical and/or environmental reasons?"*

[137] *"What is the cost of the introduction of new technologies in rolling stock, such as Automated Train Operation, the future radio system, or Digital Automated Coupling, Future Railway Mobile Communication System (FRMCS) or the "Gigabit Train" concept? What is the business case for introducing such new functionalities and technologies, and what are the barriers to implementation?"*

[138] *"What is the net extra cost of rolling stock using clean technologies as compared to diesel rolling stock? What is the nature and economic value of the investments in retrofitting of passenger and freight rolling stock?"*

[139] "Has any Member State put in place any measure for the reduction of track access charges linked to the innovative nature and/or environmentally friendly nature of the rolling stock used?"

useful data. These countries account for slightly more than 50% of the rolling stock active in the EU, according to TÜV Rheinland InterTraffic GmbH (2019), described below, and to the Statistical Pocketbook (2021). The data from the NVR has been used to compute the average age, useful life and scrapping rate of rolling stock. To compute the useful life, the difference between the date of withdrawal and the manufacturing year of scrapped vehicles is computed per type of rolling stock, and a distribution is obtained; then, the useful life is computed as the mean[140] of the distribution for each type of rolling stock. The difference between the age at scrapping (for each piece of rolling stock) and the useful life (computed per type of rolling stock) is used to identify the average remaining useful life of rolling stock that has been scrapped by the incumbent in each country.

The data from NVR presents some limitations that should be taken into account when analysing the results: (i) a small percentage (approximately 0.22% of the active rolling stock, and 0.22% of the scrapped rolling stock, all registered in Germany) has no manufacturing date; (ii) while scrapped rolling stock should be registered with the codes for mode of disposal '33' or '34', this is reported by rolling stock owners, and it is not possible to ensure the reliability of what has been reported (indeed, in some cases, rolling stock that has been coded as scrapped has later been registered again); (iii) only certain characteristics are reported in the NVR, for instance maximum speed recorded is above 160km/h, which is lower than the standard high-speed (above 200km/h); (iv) given the need to keep a minimum number of observations for each class, it was not possible to classify rolling stock according to all the possible technical characteristics that are recorded in the NVR; and (v) while the countries for which it was possible to collect data represent more than 50% of all the rolling stock registered in the EU, the extent to which the findings of this Section can be extended to other countries is unclear.

The findings of the above analyses on the conditions of rolling stock are triangulated with insights from tailored interviews with relevant stakeholders.

Section 3.3 discusses evidence of the relevance of depreciation and maintenance of rolling stock for RU, based on information that is publicly available for the Italian passenger sector only, and on insights from consultation of target groups via survey and tailored interviews.

Section 3.4 also discusses the existence of an incentive for rail incumbents to hinder access to rolling stock for other market participants. This is mainly based on analyses of NVR data. Before being allowed to circulate on the European network, rolling stock must be registered in the NVR; each piece of rolling stock is identified through the European Vehicle Number (EVN), the structure of which is provided in Appendix 6 of the Commission Implementing Decision (EU) 2018/1614. When rolling stock is withdrawn from the NVR, the latter must be updated with the withdrawal reasons according to the coding shown in Table 62 in Annex 12, and scrapped rolling stock is identified through codes 33 and 34. More information on the structure of the NVR is provided in Annex 12. The difference between the age at scrapping (for each piece of rolling stock) and the useful life (computed in the way described above per type of rolling stock) is used to identify the average remaining useful life of rolling stock that has been scrapped by the incumbent in each country.

Further evidence on this topic has been collected through the survey sent to relevant stakeholders and tailored interviews and through the existing literature. The latter only refers to Spain and the extent to which it can be generalised is limited by technical features of the Spanish railway network.

Finally, Section 3.5 presents the findings of a thorough review of the existing literature on the state of introduction of the main innovative technologies, focussing on the factors that might limit the relevant stakeholders' incentives to introduce these technologies. Tailored interviews provide further evidence on the latter. The insights of this Section apply to EU27.

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[140] All the analyses in the report have been replicated also using the median instead of the mean.

3.3 Condition of existing rolling stock

This section discusses the condition of the existing rolling stock fleet in the EU. Section 3.3.1 provides an overview of the current state, and in particular on the extent to which it has passed its useful life, making some considerations with respect to its foreseeable development in relation to the objectives of the modal shift.

Section 3.3.2 discuss the existence and drivers of technical and economic obsolescence of rolling stock. Finally, Section 3.3.3 discusses the role of public financing for the purpose of ensuring a timely renewal of rolling stock.

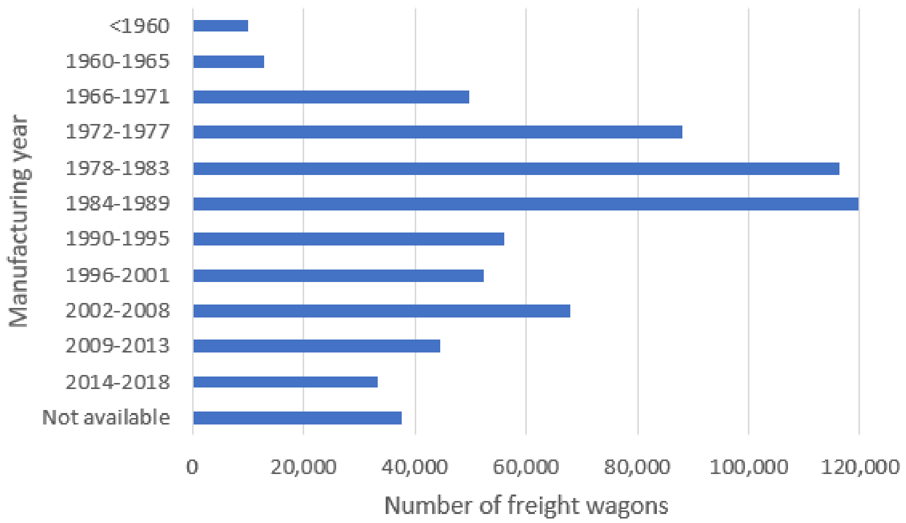
3.3.1 A snapshot of the existing rolling stock

To get a sense of the state of the existing rolling stock, the Consortium investigated the extent to which it is perceived as obsolete[141] through survey questions addressed to market regulators and industry associations. Only market regulators responded, and seven replies[142] were collected. A high degree of heterogeneity is observed in the responses collected, but some patterns can still be identified.[143] For instance, as regards passenger trains, high-speed trains were regarded in good conditions by all six market regulators who provided an answer for this category of rolling stock; in contrast, the other categories of passenger rolling stock are not considered in good conditions by the majority of respondents.[144] As regards freight wagons, though responses are quite mixed across MS and type of wagon, from the survey responses it does not seem that there is a widespread perception of obsolescence:[145] only one respondent regarded as obsolete all the types of rolling stock for which it provided a response; in contrast, the Austrian market regulator considers all types of rolling stock in good conditions.

TÜV Rheinland InterTraffic GmbH (2019) provides information on the state of modernisation of freight rolling stock in Europe. Figure 15 below depicts the distribution of freight wagons in Europe based on the year of manufacturing, as reported in the European Centralised Virtual Vehicle Register (ECVVR);[146] according to the data available in 2019, more than 50% of the freight wagon fleet in Europe was older than 30 years.

[141] Specifically, they were asked to rate different categories of rolling stock from 0 to 3, where 0 means "state of the art" and 3 "obsolete". In the report, we consider that when rolling stock was rated 0 or 1 it is regarded in good condition; when it was rated 2 or 3 it is described as obsolete or not in good conditions.
[142] From market regulators from Germany, Lithuania, Sweden, Czech Republic, Poland, Austria and Italy.
[143] For dry bulk, liquid bulk, finished goods, and regional rolling stock, responses across market regulators from different MS range from "state of the art" to "obsolete".
[144] Regional trains were considered in good conditions German, Swedish and Austrian market regulators; night trains by the Italian and Austrian market regulators; long-distance trains by Polish and Austrian market regulators. Note that the Lithuanian market regulator did not provide a response for high speed and night trains.
[145] In particular, intermodal, liquid bulk and automotive wagons are generally considered in good conditions except by one respondent. Dry bulk rolling stock is considered obsolete only by respondents; also finished goods rolling stock does not seem to be in good conditions according to two respondents, one of which is located in southern Europe.
[146] Note that for approximately 38,000 freight wagons, mainly located in Switzerland, no information was available in the ECVVR on the respective year of construction.

Figure 15: number of freight wagons per age group



Source: The Consortium based on TÜV Rheinland InterTraffic GmbH (2019).

TÜV Rheinland InterTraffic GmbH (2019) reports that the technical service life of freight wagons can be estimated to be in a range between 35 and 50 years; according to the study, the German Federal Ministry of Transport and Digital Infrastructure (BMVI) considers that freight wagons have a useful life of 40 to 50 years, whereas some wagon keepers surveyed by TÜV Rheinland InterTraffic GmbH (2019) indicated a useful life of 35 years. Approximately 10% of the freight wagon fleet was older than 50 years at the time of the study and had in theory already reached the end of its technical useful life.

In the period 2009-2018, approximately 7,800 freight wagons were put into service per year.[147] Based on this, combined with the evidence that more than 50% of freight wagons would have reached the end of their technical services life after a further 10 years, TÜV Rheinland InterTraffic GmbH (2019) estimates that more freight wagons would reach the end of their technical service life in the coming years than new wagons will be put into service.[148]

This can be considered preliminary evidence that the rate of renewal of freight rolling stock in Europe is sub-optimal and may represent an obstacle to achieving the goals of the Sustainable and Smart Mobility Strategy, particularly in light of the modal shift envisaged by the Sustainable and Smart Mobility Strategy.

To cross-check the findings discussed above, the Consortium has collected evidence about both the age and average life cycle of different types of rolling stock through the survey sent to leasing companies and RU.

The average age reported for freight wagons by leasing companies and railway undertakings is around 30 years old.[149] The average life cycle they reported for freight wagons is, in most cases, between 30 and 40 years, and in some cases higher; nonetheless, few responses were received and this evidence should be interpreted with caution.[150] In

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[147] This can be estimated from the evidence that approximately 78,000 freight wagons were registered in the ECVVR between 2009 – 2018.

[148] Indeed, around 335,000 freight wagons (more than 50% of around 650,000) would reach the end of their service life (set at 40 years), which is greater than 78,000, the number of new freight wagons that can be expected assuming the same rate of renewal observed in the period 2009-2018.

[149] In particular, the responses by five leasing companies and three railway undertakings were considered. The responses provided by one leasing company from Austria was not considered as they indicate an extremely low age and seem to represent an outlier.

[150] An average age of 27 years old was reported for locomotives by two leasing companies and one railway undertaking, with freight locomotives displaying a much lower age in the only reply received. The average life cycle is in the range 35-40 years old. The average age for passenger trains by two leasing companies and one railway undertaking is also around 27 years old, with no clear difference noticeable across different

addition, a representative from the European Union Agency for Railway (ERA) interviewed by the Consortium reported that existing rolling stock in the EU is from 30 to 50 years old.

Data from the NVR can provide further insights into the state of the rolling stock fleets for different MS and different types of rolling stock. The Consortium has computed the useful life of different types of rolling stock.[151] Table 11 reports the average number of manufactured freight wagons, passenger, and tractive rolling stock over the period 2010-2021, as well as the number of pieces of rolling stock already above their useful life and the number that will reach the end of its useful life in 10 years, aggregated across countries.

Table 11: Rolling stock renewal

Type of rolling stock	Average number of vehicles manufactured per year	Number of active vehicles already above their useful life	Number of active vehicles which will be over their useful life in 10 years	Increase in the number of obsolete vehicles[152]
Freight wagons	4,441	144,730 (38%)	236,478	91,748
Passenger rolling stock	158	10,024 (44%)	17,336	7,312
Tractive rolling stock	2,849	20,440 (22%)	32,529	12,089

Source: The Consortium based on NVR data. Note: Figures in brackets represent the percentage of rolling stock that is already above its useful life.

A substantial share of each type of rolling stock is already above its useful life, and the number will increase over the next 10 years; if the average number of new rolling stock that is put in service will stay the same as over the past 12 years, it will not be sufficient, *ceteris paribus*, to substitute the freight wagons and passenger rolling stock that are expected to end their useful life.[153] Moreover, if one considers also the rolling stock that has already reached the end of its useful life, the renewal rate for tractive rolling stock will also not be sufficient.

This implies that we are looking at a net reduction in the size of rolling stock fleet in the coming years and is an additional source of evidence that suggests that the rate of renewal of rolling stock may be sub-optimal in light of the modal shift objectives. Indeed, for this trend to be compatible with the objective of doubling rail freight traffic by 2050, the expected reduction in the rolling stock fleet size would have to be outweighed by the current spare capacity of existing rolling stock and/or the productivity gains that the introduction of certain innovative technologies (see Section 3.5) will bring about, which might not be realistic. In particular, while clear-cut evidence is not available, it is not reasonable to expect that railway undertakings have significant spare capacity, as in that case it would not be rational to even envisage substantial investments aimed at increasing rolling stock's productivity.

As depicted in Figure 45 in Annex 14, there exists a certain degree of heterogeneity among different countries both in terms of average age of the rolling stock and its useful life; this latter difference can be partially attributed to country-specific characteristics,

types of train; responses from one leasing company from the Netherlands were not considered as they indicate an extremely low age and seem to represent an outlier. The average life cycle reported for passenger trains is around 40 years old.

[151] In the analysis, the different types of rolling stock are identified as a combination of the type of freight wagon and of interoperability characteristics, according to the European Vehicle Number. A definition of the different classes, and how they have been identified, is provided in Annex 12.

[152] Here, rolling stock that has passed its useful life is considered obsolete.

[153] Results are robust to using different definitions of useful life, such as the median age of the scrapped rolling stock or 50 years as indicated TÜV Rheinland InterTraffic GmbH (2019) for freight wagons.

including different technical standards adopted in each country, and partially to how the useful life has been computed. Nonetheless, it can be observed that passenger rolling stock and freight wagons are generally older and closer to the end of their useful life, whereas tractive rolling stock is generally younger: this finding might be justified by the fact that, since the liberalisation in the early 2000s, more and more operators have been operating internationally, which requires them to endow themselves with multi-system locomotives that are relatively recent, as explained in Section 3.4. Of the six countries for which data is available, France has, on average, the oldest freight wagons and passenger rolling stock.

Table 68 in Annex 14 reports the average age and useful life for more disaggregated categories of rolling stock. As it can be observed, on average freight wagons with rigid axles tend to be older and are still used even once they reach the end of their estimated useful life. Similarly, shunting locomotives (either diesel or electric) and miscellaneous locomotives (such as those with a steam engines) tend to be used beyond their estimated useful life. While some heterogeneity in the average age can be observed also for the different types of passenger vehicles, a clear pattern does not emerge.

The Consortium discussed the state of existing rolling stock, and its adequacy with respect to the objectives of the modal shift to rail, with UIP and the EU JU. A representative from the latter commented that the renewal rate of freight wagons is very low and such that it will take around 30 years to replace the existing fleet.[154] However, he also noted that it may not be possible to make the renewal significantly faster due to limits to the productive capacity. Representatives from UIP explained that, while the condition of the existing fleet of freight wagons is adequate, the limited productive capacity represents a significant constraint to the sector's ability to meet the modal shift objective.

3.3.2 Technical and economic obsolescence

The Consortium relied on interviews with relevant stakeholders to further investigate obsolescence of rolling stock. In particular, the Consortium discussed with ERA the issue of technical obsolescence, which arises when rolling stock does not satisfy the applicable regulatory requirements and is therefore not authorised to operate.

Representatives from ERA explained that, to be allowed to circulate in the EU rail network, rolling stock has to comply with the applicable Technical Specifications for Interoperability (TSI). Once the rolling stock has been authorised to circulate, it is allowed to do so for five years, after which a renewal of the authorisation is needed. Multiple TSIs may impose requirements that rolling stock must meet, including the TSI for onboard command control, TSI for freight wagons, TSI for passenger wagons, TSI for signalling systems, and TSI for persons with disability and with reduced mobility. In addition, there are national-level operational and technical restrictions in the different MS.[155] ERA explained that the main requirements imposed by the TSIs relate to the track gauge, the shape, the electrification type and the signalling systems. When the TSIs are updated, changes are usually not retroactive and affect the authorisation requirements only for new rolling stock, while old rolling stock is still allowed to circulate until its current authorisation expires. Existing rolling stock, however, might need to be retrofitted to comply with updated requirements and to obtain the renewal of its authorisation to circulate. In this sense, updates to the TSIs can be a driver of technical obsolescence.

The extent to which existing rolling stock is technically obsolete is difficult to measure. If rolling stock is not allowed to circulate because of technical reasons, this would not be part of the NVRs, and therefore it would not be possible to identify what portion of rolling stock is technically obsolete. However, the interview with ERA suggests that technical obsolescence should not be a particularly relevant issue. This is because, generally, the guiding principle for the design of the TSI is to ensure backwards compatibility,

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[154] He observed that 20,000 freight wagons are produced each year; representatives from UIP reported instead that 10.000-12.000 wagons are produced each year.
[155] Some of these are listed in the specific "national cases" sections of the TSI (e.g., gauge, shape, signalling and type of electrification).

meaning that interoperability with the existing infrastructure, and therefore rules, is ensured; in particular, aspects of the infrastructure such as the gauge and the electrification are not subject to updates. It can be expected the main obstacle to receiving the authorisation to circulate relates to the requirements imposed by the Control-Command and Signalling (CCS) TSI (ERTMS). Though in the short run requirements to conform with the ERTMS may be a driver of technical obsolescence for existing rolling stock, this is expected to bring benefits in terms of rolling stock's availability and the costs related to its access, for the reasons outlined in Section 3.4.

The Consortium also investigated a second dimension of obsolescence of rolling stock, namely economic obsolescence, i.e. a situation that arises when the operating costs of rolling stock are high and it would be more efficient to either retrofit it or replace it with new rolling stock. The Consortium believes that, assuming that railway undertakings make rational decisions, this should occur only to the extent that there exist some constraints to the RU's ability to invest in the replacement or retrofitting of their rolling stock. The existence and nature of these constraints was investigated through tailored interviews.

The evidence collected suggests that constraints of financial nature may exist. In particular, EU JU and ERFA suggested that difficulties in the access to credit may exist, especially for small operators who may be faced with higher interest rates.[156]

An additional constraint relates to the state-owned nature of many rail incumbents. For example, since the entity that owns rolling stock is often also in control of the rail infrastructure, investing in the infrastructure will often be prioritised. This is very much different from the perspective of an operator whose core business is that of maintaining and/or operating rolling stock. Representatives of UIP explained that, for a leasing company, the decision on whether to keep wagons or invest in retrofitting or replacing them depends on several factors, but is ultimately an economic decision based on market logic.

The representative of the EU JU confirmed that the dependency on public financing implies that RU may not follow the economic reasoning that would be implied by market forces when it comes to making investment decisions; indeed, being state-owned, incumbents can expand their debts to invest in rolling stock, considering that the debt is ultimately guaranteed by the state (see also Beria et al., 2012).

3.3.3 The role of public financing to ensure rolling stock renewal

Tailored interviews carried out by the Consortium with relevant stakeholders[157] suggest that there is a strong dependency on public financing for the purpose of the renewal of passenger rolling stock.

Additional evidence on the role of public financing has been collected by the Consortium through the survey sent to market regulators and industry associations. In particular, stakeholders were asked whether the public sector provides financial support for the renewal of rolling stock and, if so, to provide an indication of the importance of public support to ensure a timely renewal of rolling stock.[158] From the responses provided by seven market regulators, it emerges that public support is generally not provided for supporting investment in freight rolling stock (and when it is, like in Austria, it is not considered important to ensure a timely renewal). In contrast, public support is more

[156] This was in particular suggested by the representative of ERFA interviewed by the Consortium.
[157] UIP and the Europe's Rail JU.
[158] Specifically, they were asked to rate public support from 1 to 5, where 1 means "not important at all" and 5 "essential to renewal"; the rate was 0 if public support is not available. In the report, we consider that when public support was rated 1 or 2, public support is considered not important; when it was rated 4 or 5, it was indeed crucial; a rate equal to 3 depicts an intermediate situation.

common for passenger vehicles, and it is considered by several respondents[159] paramount to ensuring a timely renewal of the fleet. It should be noted, however, that the picture depicted by the survey may reflect the fact that in the passenger segment a significant portion of rolling stock is purchased by state-owned entities. It is unclear whether respondents to the survey considered this as public support.

Roland Berger (2019) is the latest of three studies commissioned by the Rail Working Group, and can provide further useful indication to this end, in that it assesses the importance of private financing for investments in new rolling stock in the past decade, both in absolute terms and relative public financing. The study focuses on 590 rail vehicle procurement projects[160] in 23 countries[161] in Europe between 2015 and 2017, with an average annual expenditure of €14.95 bn.[162] Projects were classified as publicly or privately financed depending on the ownership structure of the procuring entity.[163] The available information does not allow to assess which share of both public and private financing is attributale to public service obligations. We can assume, however, that when the procuring entity was the contracting authority of a public service contract the investments were considered as public financing; and that the procurements made by privately-held entities under public service obligation contracts were considered as privately financed, at least for the portion of the investment financed by the private entity.

According to the results of the study, public financing covered most of the costs associated with the procurement of rolling stock. Indeed, 42% of the projects analysed were backed by private financing, either fully or partially; considering the value of the investments, the relative importance of public financing is even larger, as only 23% of the total value was backed by private financing. Nonetheless, there has been an increase in both the total private investment and its relevance in the structure of the projects' financing. Indeed, since 2011-2013, not only the share of privately financed projects (in number) increased from 18% to 42%, but the annual investment for the purchase of new rolling stock increased by approximately 12%, driven by private financing, which represented in 2015-2017 around 23% of the total investment, growing from 12% in 2011-2013, as shown in Annex 14. Based on these findings, the Roland Berger (2019) forecasts a further increase in the importance of private financing, which could reach up to 31% in 2023.[164,165]

While the relevance of private financing has increased over the past decade, a high degree of heterogeneity can be observed across types of rolling stock and regions. The study defined five categories of rolling stock: (i) very high-speed (VHS) and high-speed (HS); (ii) multiple units (MUs), including both diesel and electric; (iii) urban systems

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[159] In particular, public support for regional trains was deemed important by the Swedish, Polish, Austrian, and Italian market regulators; for high-speed trains by the Polish market regulator; for night trains, by the Swedish, Polish, and Austrian market regulators; for long-distance by the Polish market regulator.
[160] In the study a project indicates the purchase of at least one piece of rolling stock.
[161] AT, BE, BG, CH, CZ, DE, DK, ES, FI, FR, GR, HU, IT, NL, NO, PL, PT, RO, RU, SE, SK, TR, UK.
[162] Though most results of the study are aggregated in two wide regions, Western and Eastern Europe, the study also provides some useful country-specific insights: 409 of the projects (around 70%) were concentrated in Germany (149), France (81), Poland (58), Italy (45), UK (40) and Switzerland (34). In Western Europe, the United Kingdom and Germany accounts for 69% of the total private financing, with the UK being the country with the highest level of private financing (€1.55 bn). In Eastern Europe, Czech Republic and Poland account for 49% of total private financing.
[163] In particular, all purchases from state-owned entities were considered as being publicly financed due to government funding and explicit or implicit state guarantees; if specific project-based funding information was available and revealed private financing portions, this was taken into account pro rata even if the procuring entity was publicly held; joint ventures were considered private to the extent of the private party's share in the joint venture; procurements made by privately held entities were considered as privately financed, even if the operator purchased the rolling stock for a PSO-contract, and regardless of whether the purchase is financed by debt or equity.
[164] It should be noted, though, that this study was conducted before the COVID-19 outbreak.
[165] Note that the three-year time windows analysed by the Roland Berger studies may represent a constraint to their ability to capture all relevant recent trends regarding the role of private investment in rolling stock. Financing programs may indeed take longer. If, for instance, the period 2015-2017 was the ramp-up for a new financing program, investment may have increased significantly in the following years and this would not be captured by the study.

(US); (iv) locomotives; and (v) coaches/freight wagons. Private financing is relatively more important for purchases of coaches and freight wagons, locomotives, and HS train: for these rolling stock categories, private financing represents, respectively, 54%, 46% and 68% of the total investment. The highest level of private financing, in absolute values, is observed for MUs, although this only amounts to 18% of the total investment due to the high level of public financing. Finally, US remain almost exclusively publicly financed.

According to Roland Berger (2019), these differences can be broadly explained according to the different level of liberalisation of the market segments. High speed (HS) trains represent an exception, as private financing covers 68% of the value of the projects analysed, despite pervasive regulations in this market segment; this is due to major investment projects in UK, Spain and Italy, summarised in Table 69 in Annex 14. The other market segments in which private financing covers the biggest share of projects' value, that is multiple units, locomotives and coaches/freight cars, are those with a higher degree of liberalisation. These findings suggest that as the state of liberalisation of the rail sectors evolves as envisaged by the 2016 Fourth Railway Package,[166] the importance of private financing can be expected to further increase.

Finally, Roland Berger (2019) also analyses differences between Western and Eastern Europe. Still, as 446 out of the 590 investment projects analysed took place in Western Europe, the findings discussed above are mainly driven by what can be observed there.[167] As a general remark, the low level of investment observed in Eastern Europe may also reflect a lack of infrastructure in these MS: for instance, in several parts of Eastern Europe there is no suitable infrastructure for the deployment of high-speed trains, and it would thus not be rational to invest in this type of rolling stock.

It should also be noted, however, that the significant degree of heterogeneity in the level of private investment in rolling stock at the MS level suggests that the aggregation in the two macro-areas considered by the study may not be meaningful.

Overall, while stakeholders interviewed for the study were not able to provide a precise figure on share of private finacing for the renewal of rolling stock, it has emerged that public financing seems indeed to be needed to ensure the renewal of the rolling stock fleets in Europe, in particular for the passenger sector. Indeed, available evidence might even underestimate the current relevance of public financing, considering that compensation granted by authorities for PSO (which can be used to renew the rolling stock fleet by RU) can be exempted from notification to the Commission (see Regulaion EC 1370/2007, art. 9).[168] Consistently with this, the Roland Berger studies point to a dependence of rolling stock renewal on public budgets, even though it cannot be determined to what extent aid measures contributed to the role of public financing

Public financing seems indeed to be needed to ensure the renewal of the rolling stock fleets in Europe. The Roland Berger studies point to a dependence of rolling stock

[166] "The 4th Railway Package is a set of 6 legislative texts designed to complete the single market for Rail services (Single European Railway Area). Its main goal is to revitalise the rail sector and make it more competitive with respect to other modes of transport. […] In particular, it establishes the general right for railway undertakings established in one Member State to operate all types of passenger services everywhere in the EU, lays down rules aimed at improving impartiality in the governance of railway infrastructure and preventing discrimination, and introduces the principle of mandatory tendering for public service contracts in rail. Competition in rail passenger service markets is intended to encourage railway operators to become more responsive to customer needs, improving the quality of their services and their cost-effectiveness. The market opening is expected to deliver more choice and better quality of rail services for European citizens". See Fourth railway package of 2016 (europa.eu).

[167] The evidence from the Roland Berger study shows that in Eastern Europe: (i) total annual investment in rolling stock projects has declined steadily from €2.53 bn in 2011-13 to €1.41 bn in 2015-17, although the share accounted for by private financing has increased and is close to the share observed in Western Europe; (ii) contrary to what has been observed in Western Europe, private financing plays only a minor role in the financing of MU and HS trains. Other sources of evidence reveal certain trends in specific MS. In particular: the role of private financing in Czech Republic has gradually been increasing, in parallel with increasing liberalisation of the rail passenger segment; in Slovakia there is limited procurement of rolling stock, because the main suppliers of rail transport services are RU from other countries.

[168] EUR-Lex - 32007R1370 - EN - EUR-Lex (europa.eu).

renewal on public budgets, even though it cannot be determined to what extent aid measures contributed to the role of public financing.

If State aid is granted for this purpose, in assessing the compatibility of State aid with the rules of the internal market "the Commission will take care to avoid undue distortions of competition, notably by taking account of the additional revenue that the replaced rolling stock on the line in question could procure for the enterprise aided, for example, through sales to a third party or use on other markets".[169] Therefore, in assessing the need for State aid, proper consideration should be given to the actual value of the rolling stock.

The Consortium investigated the extent to which book value of rolling stock can be considered a good proxy for its market value through the survey sent to RU and leasing companies. They were asked to report the margin they would expect to earn from the sale of a piece the rolling stock (for different levels of amortisation). Ten responses[170] were collected. A rather high degree of heterogeneity is observed in the responses,[171] but some patterns can still be identified. Specifically, respondents expect to earn a positive[172] margin, and this margin increases with the percentage of amortisation already sustained. In conclusion, evidence from the survey suggests that a difference between book and market value might indeed exist,.and that the market value of rolling stock might in particular be larger than its book value.

The Consortium attempted to collect further evidence of the topic, and in particular on the extent of this difference, through tailored interviews to two of the main stakeholders representing vehicle owners, including UIP and one that has expressed the desired to not be disclosed. The latter was able to provide some information: its representative noted that there may exist significant differences in the rules adopted by vehicles owners for the amortization of rolling stock, and in particular in the length of the time span over which rolling stock is amortized. They explained that one important driver of these differences is the fact that the expected level of usage of rolling stock, which may differ between rolling stock used for different reasons, is likely to be considered for amortization rather than age (e.g., rolling stock used for intermodal transport is expected to be used much more than rolling stock used for conventional freight transport). To some extent, the level of usage a piece of rolling stock will have to handle can be predicted at the beginning of its life cycle based on the service that it will be employed for.[173] Another factor that may generate systematic differences in the amortization rules adopted across different MS, they noted, relates to the policy priorities of different MS: in MS with a higher focus on sustainability, vehicle owners may have an incentive to amortize rolling stock over a relatively longer period; on the contrary, if a MS is more focussed on promoting innovation and has the resources to invest in it, this may be reflected in a shorter amortization period chosen by the vehicle owner.

Representatives of UIP confirmed that there can be differences in the time span over which freight wagons are amortized by private wagon keepers, which can range from 30 to 40 years, depending in particular in internal strategic decisions. However, they also noted that state-owned RU follow the amortization rule defined by the UIC leaflets,[174] and in particular amortize freight wagons over a 20-year time span with a 4% yearly depreciation rate; the remaining 20% of the original value corresponds to the residual value of the wagon, that is the value of the steel.

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[169] Railway Guidelines, § 37. EUR-Lex - 52008XC0722(04) - EN - EUR-Lex (europa.eu).
[170] From railway undertakings from Sweden, Slovakia, and Lithuania, and from leasing companies from Germany (2), Sweden (2), Netherland, Lithuania, Spain.
[171] For example, the margin for freight rolling stock with 75% of costs amortised ranges between 5% and 95.5%.
[172] The only respondent which identified a negative margin is Arlanda Express, a Swedish passenger railway undertaking. Nonetheless, given the magnitude, it seems a misreport.
[173] For instance, it can be expected that locomotives that will be destined to intermodal transport will be used much more over the same amount of time than locomotives used to move some other types of freight.
[174] These were the rail standards prevailing before the creation of the European Rail Agency and the TSIs.

Desk research carried out by the Consortium confirms the existence of relevant differences in the amortization rules adopted around EU, both across MS and within the same MS. In particular, the Consortium collected information on the expected useful life of rolling stock, hence the period used for its amortization, from the financial statements and reports of rail freight[175] incumbents in the six MS covered by the NVR data and found that in France it is 30 years, in Germany it ranges from 10 to 30 years, in Italy from 23 to 30 years, in Spain from 20 to 40 years, in Slovakia from 32 years to 40 years, in Poland from 36 to 48 years.176 In addition, information on the period of amortization adopted in Slovenia for freight rolling stock was collected: this ranges between 36 and 48 years for freight cars, and between 24 and 45 for electric locomotives. The Consortium also collected information on the way in which amortization is distributed along this time span (e.g. constantly or through a decreasing depreciation charge). This is not always explicitly declared but, where available, the evidence points to a constant rate of depreciation.

The Consortium has compared the above evidence on expected useful life of rolling stock from financial statements with incumbents' rolling stocks average useful life, as computed from the NVR data. In most cases, the average age of rolling stock is higher than its useful life, even considering the upper bound reported in the financial statement,[177] consistently with the results of the analyses discussed in section 3.3.1. This can be interpreted as evidence that, on average, rolling stock's market value in these countries tends to be larger than its book value.

It should be noted, however, that rolling stock's market value does not depend solely on its age. A representative of one of the main associations representing vehicle owners interviewed by the Consortium explained that several factors affect rolling stock's market value, other than its age. These include the level of usage and the availability of spare parts and/or upgradability of components. As regards the latter, there is a risk that due to technical innovation certain spare parts are not produced anymore and thus cannot be found on the market. As a result, the market value of rolling stock which may be not repairable and or/upgradeable will be affected. In these cases, it can happen, indeed, that even relatively young rolling stock might have to be scrapped if it breaks. Finally, the introduction of new technical requirements, through the update of the relevant TSIs, may significantly reduce the market value of rolling stock, when the costs associated to its upgrading to make it compliant with the new TSIs are too high and the owner is not willing or able to sustain them. Representative of UIP pointed out other determinants of the leasing prices of rolling stock, which include the cost (and not only the avaialability) of spare parts needed for maintenance, and in particular the cost of wheelsets; the current price of steel which in turn affects thet scrapping value; and the current market demand for the wagon. They noted that these factors crucially depend on the specific type of wagon.

This implies that there can be significant variability in the residual market value of rolling stock pieces of the same age, and in particular between the market value of rolling stock pieces tha have already reached the end of their useful life. Finally, the absence of a well-functioning second-hand market at EU level does not provide market signals on how these considerations are factored in the valuation of rolling stock.

Taking into due consideration all the limitations discussed above, the available evidence seems to suggest that rolling stock's market value may be on average larger than its book value, though it is not possible to provide a quantification of this difference. The available evidence thus suggests that if the aid is granted based on the book value, this

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[175] For Italy only, the information reported is not specific to freight rolling stock, and refers instead to both the passenger and freight segment.

[176] It is important to stress that financial reports do not generally specify the specific assets that are included in the reported estimates. For example, as regards Slovakia, the figure refers to "machines" in general, not to rolling stock specifically. This may imply that the lower bound is not informative of the period of amortisation of rolling stock pieces.

[177] The analysis was focussed on freight wagons, given that this is the type of rolling stock that typically has a longer life, thereby making its age more directly comparable to the upper bound of the expected useful life reported in the financial statement.

may not reflect the actual market value of the rolling stock, leading to an over or under-estimation of the intensity of aid needed.

CONCLUSIONS:

The available evidence suggests that the condition EU rolling stock fleet may be inadequate to support the growth of the rail sector that would be requested to meet the modal shift objectives, in particular in the passenger segment. A significant portion of the fleet has already passed its useful life. The size of the rolling stock fleet that is approaching the end of its useful life implies that we are heading towards a reduction in the size of rolling stock fleets. This situation seems to arise also because smaller RU may be financially constrained. Although the relevance of private investment in the railway sector has been increasing over the past decade, State aid seems to still be needed to ensure the renewal of the rolling stock fleets.

3.4 Access to rolling stock

The situation depicted in section 3.3 above may be explained by the significant costs related to access to rolling stock.

The fact that access to rolling stock represents a significant barrier to entry in railway markets seems well established. From the *fitness check* of the Railway Guidelines carried out between 2019 and 2020 by the European Commission, it emerged that access to rolling stock represents a major barrier to entry in the railway markets. Further, Laisi et al (2012) investigate the main barriers to entry to deregulated Polish and Swedish rail freight market through, *inter alia*, consultation with relevant stakeholders, and finds that acquisition of rolling stock is commonly reported as one of the main entry barriers. Bougette et al (2021) include rolling stock among complementary assets that are deemed as quasi-essential for an efficient and effective entry in the market.

The Consortium has investigated which factors contribute to make access to rolling stock more complex in certain market segments (freight and passenger) and geographic areas: these mainly relate to the degree of technical standardisation of rolling stock, and are discussed in Section 3.4.1. To address study question 17, the Consortium collected evidence on the incidence of depreciation and maintenance costs of rolling stock on the cost structure of RU; this is discussed in Section 3.4.2, which, however, also explains why this metric may not adequately represent the significance of the costs related to rolling stock for a RU. Lastly, Section 3.4.3 discusses the importance and functioning of the second-hand market for rolling stock, with particular focus on the role played by the economic incentives of incumbents.

3.4.1 Technical standardisation of rolling stock and the leasing market

From tailored interviews with relevant stakeholders[178], it emerged that access to locomotives and passenger rolling stock is particularly complex and costly. The main driver of this complexity is the lack of technical standardisation of rolling stock across Europe, which is the result of differences in the rail infrastructure across different MS. Railway systems have been built and upgraded by individual MS independently from one another; in order to be allowed to circulate in a MS, rolling stock must satisfy certain technical requirements which might differ across MS due to differences in the infrastructure. As a result, rolling stock is ultimately tailor-made for each network, and might not be able to circulate in MS where the network is different, unless significant investments are made.

A representative of the EU JU explained that the differences in the rail infrastructures that represent an obstacle to the standardisation of rolling stock across MS relate to:

- the signalling systems: these represent the main factor limiting standardisation of rolling stock, thus ultimately influencing its cost and availability. For instance, the high-speed train Eurostar needs eight signalling systems to travel from London to Amsterdam; for journeys that cross the North-South Corridor, it may

[178] Europe's Rail Joint Undertaking, a European partnership on rail research and innovation; UIP; ERFA; and ALLRAIL.

be necessary to use locomotives such as Vectron that can handle up to 17 signalling systems. This lack of standardisation makes the provision of cross-border rail transport services costlier, and more prone to failure, as compliance with several systems at the same time must be ensured; it also makes the manufacturing process of rolling stock longer. This issue could be overcome by adopting the EU-wide standards envisaged by the European Rail Traffic Management System which should replace national signalling systems and procedures, but whose current rate of deployment is still unsatisfactory;
- the electrification and voltage systems: different Member States have different rules concerning voltages. However, modifying this aspect would be complex as it would require to intervene on the electric infrastructure, besides the rail infrastructure: the consequence is that multi-power locomotives are needed, which entail higher costs;
- the gauge, which in certain MS, and in particular in Spain[179], Portugal, Ireland, Finland and in various states in Eastern Europe, is different than the standard gauge of 1435mm prevailing in Europe.

The lack of standardisation represents a technical barrier which prevents rolling stock to be exchanged across different MS, and therefore limits the existence of a wide and well-functioning leasing market. Leasing companies are of prominent importance to make rolling stock accessible at competitive prices to RU since they provide liquidity to the market, and give RU flexibility, in that the short-term length of the leasing contract allows them to modify the composition of their fleet based on changing market needs, and this can also be done timely given that waiting times are shorter with respect to the option of purchasing new rolling stock. Hence, leasing companies ultimately lower the investment needed to access rolling stock. SCI Verkehr has published a study in 2021[180] that discusses the importance of leasing companies, with a particular focus on locomotives, for promoting competition in rail market, showing that in the years 2010-2020 the fleet of leasing companies has significantly grown in parallel with the increasing importance of entrants.

According to the study, approximately 10% of the mainline and shunting locomotives in with an active registration in Europe, Switzerland and Norway in 2020 were owned by leasing companies. These locomotives are mostly used for freight transport; indeed, 21% of mainline electric freight locomotives and 13% of diesel freight locomotives belong to leasing companies, whereas only 3% of locomotives used for passenger transport are owned by leasing companies. Moreover, the growth of the leasing market for locomotives is remarkable: while they represented around 25% of new locomotives registered between 2011 and 2015, the number grew to 40% of new registrations between 2016 and 2020. This also implies that these locomotives are interoperable with new technologies (such as ETCS) and across different railway networks.

The overall growth of the leasing market (not limited to locomotives) may prove particularly important to foster the development of markets where second-hand rolling stock is exchanged, since rolling stock lessors are the main players in these markets, as suggested by representatives of one of the main associations representing vehicle owners.

Still, there are differences between the freight and passenger sectors: leasing companies' presence is much stronger in the rail freight segment, whilst it seems marginal in the passenger segment. In particular, leasing companies own more than 50% of the fleet of freight wagons in the EU;[181] their role for locomotives is currently more limited (leasing companies own around 10% of the locomovites fleet in

[179] Additional details on the differences of the Spanish gauge with respect to the standard gauge are discussed below in this Section.
[180] The study covers EU+CH/NO. See Sci Verkehr "European rolling stock leasing fleet Market overview for freight and passenger assets", commissioned by the Association of European Rail Rolling Stock Lessors (AERRL). The study is not available online but can be requested to AERRL.
[181] As reported by the representative from UIP.

EU+CH/NO) but is growing.[182] The main association representing around two-thirds of the locomotive fleet of rolling stock lessors is AERRL (Association of European Rolling Stock Lessors).[183] As regards the passenger segment, SCI Verkehr (2021) also shows that:

- 7% of the Multiple Units' fleet is owned by leasing companies, and the vast majority of this portion is concentrated in Germany;
- the leasing of passenger coaches is a niche market in Continental Europe, representing less than 1% in the total fleet.

Tailored interviews carried out by the Consortium with members of UIP and ERFA revealed that it has become increasingly common for freight RU to sell their freight wagons fleet and lease it back. Representatives from UIP explained that many RU prefer not to deal with maintenance of rolling stock and to focus on their core business (i.e., the operation of rolling stock for the provision of rail freight services). For instance, Société Nationale des Chemins de Fer (SNCF), Deutsche Bahn and Lineas have been doing this in France, Germany and Belgium respectively. Rail freight operators can do this because they know freight wagons are easily accessible, and they will timely find rolling stock when they need it. Some shipping companies even provide their own wagons. This option is not available in the passenger segment.

Specific evidence on the Spanish leasing market has been drawn from the existing literature. Vicente Mampel (2019) analyses the rolling stock leasing market in Spain, and provides further evidence that the concern that rail incumbents may hinder access to rolling stock for competing operators may be well founded. According to the author, the bulk of the offer of locomotives is provided by the state-owned Renfe Alquiler (controlled by Renfe-Operadora, the incumbent RU in both the freight and passenger segments), with other suppliers active in the market providing almost only the most modern types of locomotives. Its strong position as a supplier, according to Vicente Mampel (2019), seems to have allowed Renfe to impose unfair conditions on the lessees. The study argues indeed that, while the prices charged by Renfe for the lease of state-of-the-art locomotives, which are the only ones subject to the competitive constraints exerted by other leasers, are in line with those set in the market, the prices charged for older locomotives, which are virtually subject to no competitive constraint, are considered to be disproportionate if compared to the residual value of the rolling stock. This suggests that prices charged by the incumbent-controlled leaser may reflect a certain degree of market power.[184]

However, the extent to which these findings can be generalised to other MS is limited, to the extent the Spanish railway is characterised by a broader gauge (the so called "Iberian gauge") which coexists with the standard gauge: this might contribute to the picture depicted by Vicente Mampel (2019), in that it may represent an additional source of market power for the Spanish incumbent. This was confirmed by a representative from UIP interviewed by the Consortium, who explained that the different gauge of the Spanish infrastructure makes the Spanish market for the provision of rolling stock less attractive for leasing companies whose presence in the Spanish market is marginal. As a result, Spanish RU are captive to the national supply of rolling stock. A representative from ERFA confirmed that access to freight rolling stock can be relatively more complex in a MS characterised by a gauge different from the standard one.

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[182] Locomotives lessors include: Akiem, Railpool, MRCE, Beacon Rail, Cargounit, Northrail, ELP, which are all members of AERRL, as well as Alpha Trains and ELL. Part of these companies, and in particular Railpool, Akiem, Beacon Rail, Alpha Trains and Northrail, are also active in the leasing of Multiple Units, together with other operate and finance leasing companies including DAL, 3i, Societe Generale and Industrial Division.

[183] There figured are reported in SCI Verkehr (2021), though note that they do not reflect a further increase in the AERRL's fleet, due to the fact that Renfe Alquiler joined the association after the study was carried out.

[184] Other leasing conditions imposed by Renfe may distort competition in the market, including the fact that the leased rolling stock has to be maintained by Renfe's own maintenance company; and that third-party lessees are required to insure the rolling stock for a high value – a requirement which does not apply to the rolling stock leased to companies controlled by Renfe, leading to asymmetric leasing conditions in the market.

3.4.2 Evidence on the incidence of the costs related to access to rolling stock and its maintenance on RU's cost structure

The Consortium has tried to collect quantitative evidence on the incidence of depreciation and maintenance costs of rolling stock on the overall cost structures of a RU, as requested by study question 17. Before discussing the collected evidence, it should be noted, however, that the increasingly important role of the leasing market discussed above significantly limits the relevance that can be attributed to this metric for the purpose of assessing the significance of the costs related to rolling stock for a RU. Indeed, if the rolling stock is leased through operating leasing, and the leasing company is responsible for its maintenance, there will be no depreciation and maintenance costs associated to that rolling stock (but of course the RU will pay a leasing rate).[185] This also significantly limits the extent to which the incidence of depreciation and maintenance costs can be meaningfully compared across different freight RU, as the extent to which RU lease their fleet may be heterogenous.

The evidence on the incidence of depreciation and maintenance costs on the cost structure of RU that the Consortium was able to gather from publicly available information and the stakeholder survey is limited.

A document prepared by the Italian rail passenger incumbent, Trenitalia, on the rules for the preparation of the financial statements,[186] provides some estimates of the incidence of these cost items on the cost structure of passenger RU. Assuming an "efficient cost structure"[187] and service quality in line with the Italian average, depreciation (plus the cost of invested capital) and maintenance costs of rolling stock amount to significant shares of total costs, namely 30% and 20%, respectively. It should be noted that these estimates concern only the Italian rail passenger transport, and the extent to which these can be extended to the freight market and to other MS is unclear.

Additional evidence was gathered through the survey sent to RU. Only two railway undertakings responded: a freight RU and a Swedish passenger RU.[188] The estimated maintenance costs account for around 8% of the overall costs structure, but depreciation costs differ according to the market segment (passenger or freight). In the passenger segment, they accounted between 5% and 15% in the last two years, while they were lower in the freight segment.

Given the unsatisfactory response rate to the survey, the Consortium has tried to collect further information through tailored interviews, but did not manage to obtain quantitative estimates. Representatives from ALLRAIL explained that an estimate of the incidence of these costs that is applicable to all counties in EU and to all operators cannot be provided, because several factors contribute to generating significant differences across MS for three different reasons: first, the magnitude of costs associated to maintenance of rolling stock is influenced by the cost associated to access to maintenance facilities, which are highly variable; in particular, it was suggested that, since these facilities are mostly owned and operated by infrastructure managers which are vertically integrated with rail incumbents, independent RU may face higher costs. Second, costs associated to the labour required by maintenance may also vary across MS. Third, the level of track access charges varies significantly across MS: since this

[185] On the contrary, with financial leasing the lessee would also be required by accounting rules to register the asset in their balance sheet, and the corresponding depreciation in the P&L statement. However, representatives of UIP consulted by the Consortium reported that operating leasing is the prevailing form of leasing contract in the freight segment. They also noted that financial leases may instead prevail for the leasing of Multiple Units; for instance, EUROFIMA offers financial lease solutions for this type of rolling stock. This is also confirmed by SCI Verkehr (2021), where the importance of bank and financial leasing relative to that operating leasing companies is larger for the Multiple Units segment than the locomotives segment.

[186] See "Misure regolatorie per la redazione dei bandi e delle convenzioni relativi alle gare per l'assegnazione in esclusiva dei servizi di trasporto pubblico locale passeggeri e definizione dei criteri per la nomina delle commissioni aggiudicatrici", Trenitalia, 2015, available here https://it.readkong.com/page/misure-regolatorie-per-la-redazione-dei-bandi-e-delle-4514761.

[187] The document provides neither a definition of "efficient cost structure" nor any benchmarks for comparisons.

[188] The Swedish passenger RU is Arlanda Express, the freight RU has opted for its data to only be disclosed in aggregate form.

affects the overall costs of a railway undertaking, it influences the incidence of depreciation and maintenance costs of rolling stock and does not allow to provide a meaningful cross-country comparison.

Finally, the Consortium also investigated through tailored interviews whether these figures can be expected to significantly differ between rail freight and passenger operators. A representative from UIP noted that, while quantitative estimates are not available, it can be expected that costs related to accessing rolling stock and its maintenance represent a larger portion of total costs for freight operators. This is because while the cost of purchasing rolling stock is higher for passenger operators, other cost items, such as personnel costs, weigh less for freight operators, increasing the incidence of depreciation and maintenance. It should be noted that this applies to operators owning their entire rolling stock fleet, which, as explained above, now represent a minority of freight operators. The larger the portion of the rolling stock fleet that is leased on the market, the lower will be the impact of depreciation and maintenance costs for a freight RU, *ceteris paribus*. This might explain why this expectation does not seem to be confirmed by the limited evidence collected through survey response discussed above.

3.4.3 The second-hand market for rolling stock

The Consortium investigated the extent to which access to second-hand rolling stock can help foster competition in railway markets, and whether markets where second-hand rolling stock is leased or sold can be considered to be well-functioning and/or sufficiently developed.

Given the potential importance of these markets, the Consortium also investigated how they function in practice, and in particular whether there exist economic subjects that offer services aimed at facilitating the exchange of used rolling stock. Railvis.com is an independent online marketplace for the exchange or lease of both new and used rolling stock of all types, from all Europe.[189] Offer prices are, in some cases, available for members, in other cases they are available upon request; in some cases, finally, the exchange price is determined through auctions. The extent to which platforms like this one are used is unclear. Available evidence suggests that bilateral negotiations are the prevailing form through which rolling stock is exchanged. This was suggested by members of one of the main associations representing vehicle owners interviewed by the Consortium and confirmed by representatives of UIP. The latter also explained that used freight wagons are exchanged through tenders at the EU level: information on the selling price is not disclosed. Desk research carried out by the Consortium allowed to identify other services that facilitate negotiations aimed at exchangind rolling stock.[190]

Overall, the available evidence suggests that markets for second-hand rolling stock may not be developed enough: in particular, representatives of one of the main associations representing vehicle owners reported that the demand for used rolling stock may be larger than its supply.

The lack of technical standardisation described above has an impact also on the second-hand markets. Specifically, it makes markets for second-hand rolling stock mainly national in scope. This applies to a lesser extent to rail freight operators, since only locomotives are affected by the differences in the infrastructure. On the other hand, freight wagons can circulate in the whole European rail infrastructure that is characterised by the standard gauge.

[189] Currently, offers from several European countries can be found (e.g., Germany, France, Italy, Hungary and Serbia).

[190] For instance, Railmarket.com is an online platform connecting railway companies and professionals across the rail market in general, which can in particular be used as a specialised search service for used rolling stock. Progress Rail, a subsidiary of Caterpillar which acts as a worldwide supplier of tractive rolling stock, sells rolling stock, including used one, also through its website; prices are not publicly available. It seems also that there are companies, such as SCI Verkehr GmbH and Railistics, proposing among their consulting services valuation of rolling stock.

As a result of this mostly national dimension of the second-hand markets, there is a concern that rail incumbents may contribute to making access to rolling stock costlier for other market participants. Entrant RU, indeed, cannot source used rolling stock from other MS. Rail incumbents are the main suppliers of used rolling stock in each MS, given that prior to the liberalisation of the rail markets they were the only buyers of rolling stock. They may have an incentive to leverage their strong position as a supplier to hinder access to rolling stock for existing or potential competitors, as their interests conflict with that of lowering barriers to entry and/or expansions of competitors, which would imply increasing the level of competition they have to face.

The upshot is that incumbents may have an incentive to scrap or keep in storage rolling stock that they do not need and could still be used, instead of selling or leasing it to other market participants. On the 10th of June 2022, the Commission has sent a Statement of Objection to the Austrian and the Czech passenger incumbents as, between 2012 and 2016, the two incumbents have allegedly coordinated to hinder access to rolling stock to a specific competitor operating only in the Czech Republic and on the international route between Vienna and Prague.[191] In France, the incumbent SNCF owns and operates the Ouigo trains, which are low-cost passenger trains; the French Transport Regulatory Authority (ART), as well representatives of entrants, such as Transdev and FlixTrain, have expressed the concern that the incumbent refuses to sell its older trains to entrants, contributing to make barriers to entry and/or expansion higher.[192]

Evidence collected through the survey signals that incumbents may engage in this behaviour: responses to the survey suggest that incumbents in Western Europe are indeed perceived, by other RU as well as by leasing companies, to have a preference to scrap rolling stock rather than sell it or lease it on the market. In particular, two freight leasing companies[193] have claimed that the absence of a second-hand market at the national level is due to the behaviour of the incumbent that indeed prefers to scrap rather than sell its used rolling stock. However, the response rate is low, and the incentives of respondents may be non-neutral.

Responses to other survey questions seem to provide a somehow contradictory picture. In particular, RU were asked to provide an indication of the percentage of their rolling stock fleet that was scrapped in the previous year, as well as of its average age. However, only for the freight segment responses were received by both incumbents and entrants, and even in this case the evidence collected cannot be considered conclusive as only three RU replied; all reported that they have scrapped less than 5% of their fleet last year; the average age reported ranges from 34 to 55 years old, and the highest age was reported by the only rail freight incumbent who responded. However, the difference in the age may be justified by the different types of rolling stock the response referred to.

The Consortium investigated the existence of non-neutral incentives of the incumbents also through tailored interviews. A representative from the EU JU noted that the economic incentives of RU limit the extent to which second-hand rolling stock is exchanged within a national market. In particular, rail incumbents have no incentive to make rolling stock available at favourable economic conditions for existing or potential competitors. Representatives from ALLRAIL confirmed that the rail passenger incumbents generally prefer to scrap the rolling stock or to keep it as a reserve, and are reluctant to make it available for actual or potential competitors in the same country. Representatives from ALLRAIL also observed that, in contrast, in the past that rail incumbents from different MS have exchanged rolling stock with each other. The fact that rail incumbents may keep rolling stock with low or no levels of usage, and that this may hinder the development of the markets for used rolling stock, was confirmed by

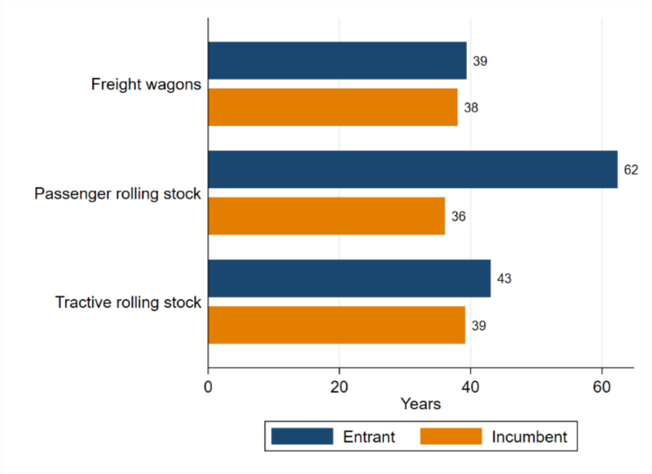
[191] See the press release of 10 June 2022, available on the European Commission's website.
[192] See "Slow progress: French market entry still difficult for private operators", by Preston R. (2022), available here.
[193] Nexrail Lease Sarl from Netherland, and Sandahls Equipment AB from Sweden.

members of one of the main associations representing vehicle owners interviewed by the Consortium.

The behaviour of incumbents can be analysed through the NVR data. The Consortium has compared the average age at scrapping between entrants and incumbents. The idea is that, if rail incumbents systematically scrap rolling stock that could still be used, a difference should be observed in the average age of rolling stock scrapped by rail incumbents and other market participants that have no incentive to engage in this behaviour. In particular, the difference should be such that the former is higher, unless there are other factors that systematically differ between the two groups and would have the opposite effect.

The results of this analysis are presented in Figure 16 below: entrants, on average, scrap at higher ages than incumbents, with the difference being particularly marked for passenger rolling stock.[194]

Figure 16: Average age at scrapping



Source: The Consortium based on NVR data. Note: the average age at scrapping has been computed as a weighted average across MS and type of rolling stock, where the weights are the number of pieces of rolling stock owned by incumbents and entrants with a valid registration to operate on the railway network.[195]

The findings of this analyses alone cannot be considered as clearcut evidence that incumbents scrap rolling stock that could be reused, *inter alia* because it may be the case that incumbents are constrained to a lesser extent than entrants in their ability to invest in the replacement of rolling stock when it is efficient to do so.

To understand whether incumbents also scrap more rolling stock, and at a faster rate, the evolution of the 2010 total fleet of entrants and incumbents, and in particular how it has evolved over time due to scrapping, has been compared, as shown in Figure 17 below.[196]

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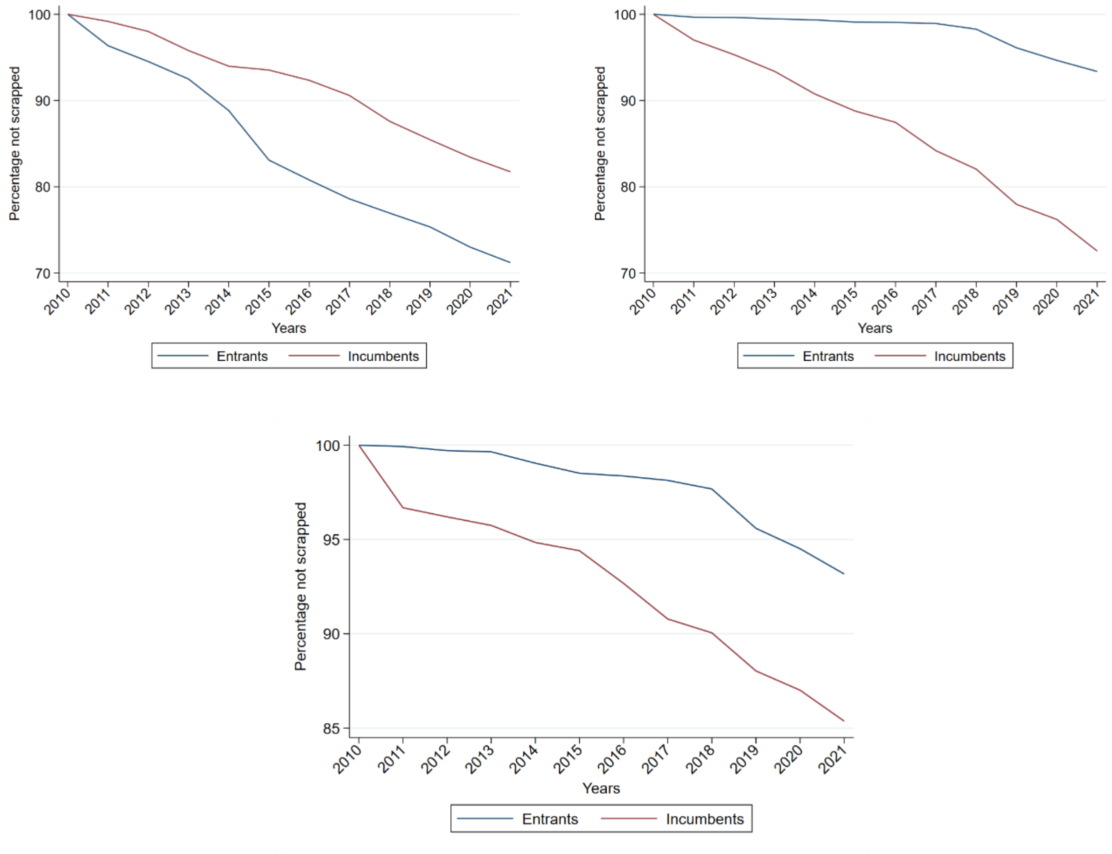
[194] Results are mostly robust to the use of the median age at scrapping. Indeed, the incumbents still scrap younger rolling stock, except in the case of tractive rolling stock.
[195] Weights have been assigned on the basis of the size of the fleet of incumbents and entrants in different countries and for different types of rolling stock. In this way, the German incumbent, having a larger fleet than the Slovak incumbent, will weigh more.
[196] New rolling stock built after 2010 to renew the fleet is not considered.

Figure 17: Rolling stock not scrapped as a share of the 2010's fleet, freight wagons (left), passenger rolling stock (right) and tractive rolling stock (bottom)



Source: The Consortium, based on NVR data.

The graph shows that, in the period 2010-2021, incumbents have scrapped a lower percentage of their freight wagons fleet, whereas a much higher percentage of their 2010 passenger rolling stock and locomotives was scrapped over the same period. It should be noted that, while in principle these results could be explained by the fact that entrants' fleet can be expected to be generally younger, which was also suggested by CER during an interview with the Consortium, this explanation does not seem to apply in this case: while the average age of freight wagons is almost the same in 2010 (37 years for incumbents and 36 years for entrants), there is a difference in the average age of passenger and tractive rolling stock, but entrants' fleet is actually 30 years and 7 years older, respectively.

The results of the analysis are confirmed also by a further quantitative analysis presented in Annex 12.5, which estimates the difference in the probability, between incumbents and entrants, that rolling stock will be scrapped, controlling for the size of the fleet of operators and the age of the rolling stock. Overall, the analyses presented above seem to lend credibility to the concern that incumbents might have an incentive to hinder access to rolling stock to restrain competition in the passenger segment, which, according to the Statistical Pocketbook (2021) is also less competitive than the freight segment, by reducing access to used rolling stock. Results for the freight segment are less clear, as incumbents seem to be scrapping relatively more rolling stock than entrants, but only for what concerns tractive rolling stock.

The evidence discussed in this section suggests that incumbents may indeed have an incentive to scrap rolling stock that could still be used, especially for the passenger sector. As suggested by the stakeholders mentioned above, this may limit the development of second-hand markets for rolling stock, to the extent that there would be demand for the rolling stock scrapped. However, this behaviour may have a substantial impact on actual or potential competition only to the extent that access to second-hand rolling stock cannot be effectively substituted by other sources, and in particular by the option of purchasing or leasing new rolling stock.

The 7th RMMS report claims that the lack of adequate rolling stock available in the second-hand market or in the leasing market is "a significant deterrent for market entry and fair competition", in particular for rolling stock which requires technical standardisation, i.e. locomotives. The lack of interoperability across countries could thus be another factor affecting the second-hand market. The Consortium explored the importance of access to second-hand rolling stock for market entrants through tailored interviews. The overall evidence collected through the interviews suggests that access to second-hand rolling stock would be important mainly for passenger operators.

A member of EU JU noted that access to second-hand rolling stock could prove very important for the competitiveness of small operators, as it would significantly lower the investment needed. This is not only because the option of purchasing new rolling stock is more expensive; but also, because it requires dealing with the manufacturers, which tend to prioritise large orders. Furthermore, the purchase of rolling stock is characterised by long waiting times: access to second-hand rolling would drastically reduce the waiting time, thus the time needed to be competitive in the market. The importance of access to second-hand rolling stock was confirmed also by members of one of the main associations representing vehicle owners.

As regards freight wagons, a representative from UIP explained that the age of freight wagons is not particularly relevant for its users as long as they are fit for purpose: freight wagons have a long useful life, and while older freight wagons will have a lower residual value (hence buying a used wagon will be cheaper), the pace at which they lose their value is not as fast as for other types of rolling stock.[197] This suggests that the second-hand market does not deliver significantly lower prices compared to new rolling stock.

In addition to this, ERFA explained that as most freight operators nowadays operate cross-border, and thus need multi-system locomotives, which are relatively recent, the supply of second-hand locomotives would not meet their needs. However, access to second-hand locomotives may become important in the future to reduce barriers to entry and/or expansion. ERFA also reported that they are not aware of any preferential treatment towards large orders by the manufacturers. It should also be noted that UIP explained that manufacturers of freight wagons are generally happy to also serve small orders and not be dependent on a few undertakings. It may thus seem that the size of the order is mainly considered when it comes to the purchase of passenger rolling stock.

CONCLUSIONS:

Access to passenger and tractive rolling stock seems to be particularly complex. The main driver of this complexity is the lack of technical standardisation of rolling stock across Europe, which is the result of differences in the rail infrastructure across different MS. This complexity has affected the development of both the leasing and the second-hand market for passenger and tractive rolling stock. There is also some evidence that incumbents might have the incentive to scrap used rolling stock rather than selling it on the market. As technical standardisation does not seem to be a limit for freight wagons, these concerns seem to affect the freight sector to a smaller extent.

3.5 Modernisation of existing rolling stock

The introduction of innovative and/or clean technologies can lead to a reduction in the emission of CO^2 and other pollutants in both a direct and indirect way. Not only switching to clean propulsion systems will have a direct impact on the reduction of emissions, but the introduction of new technological solutions can also lead to an increase in the productivity of rolling stock and in the capacity of the existing network, thus reducing

[197] This also implies that there exists a market for second-hand freight wagons only as a result of the fact that railway undertakings have been selling their rolling stock fleet to companies that take care of its renewal and maintenance and lease it on the market.

operating costs, enhancing the modal shift to rail and ultimately leading to lower emissions. Some of the technologies analysed below are still at an early stage, sometimes to the point that only prototypes are available. This implies that unforeseeable difficulties might arise, and that RU may have the incentive to wait until their adoption becomes either widespread in the sector or a new mandatory standard. Moreover, in order for the adoption of new and clean technologies to become widespread, interoperability with the existing infrastructure and rolling stock needs to be ensured, lest the associated costs become too much of a burden for RU, and disincentivise the adoption of these technologies.[198]

Indeed, the issue described above has been raised by stakeholders that have been surveyed for the study: three leasing companies[199] have claimed that an uncoordinated migration could hinder the introduction of innovative technologies, at the very least to the extent that it would increase the bureaucratic burden that operators need to sustain to obtain the authorisation for the rolling stock to operate in countries with different technological standards. Moreover, representatives from both ERFA and ALLRAIL have claimed that, as the railway network is congested, investing in innovative technologies would not be worthwhile as RU could not reap the benefits that would derive from the increased potential capacity, as the existing network is not able to sustain an increase in supply.

Policy interventions could thus be needed to incentivise the migration towards innovative and clean technologies. Subsidies to first movers (i.e., those operators who undertake the risks and start an early migration to the new technologies) could mitigate the issue (see, *inter alia,* Katz and Shapiro, 1986, and Rauch, 1993, for the efficiency of subsidies to address first-mover disadvantage), although representatives of the European's Rail Joint Undertaking and ERFA have claimed that it would not be enough; instead EU-wide coordination is essential to incentivise the development and migration towards innovative technologies; some policy interventions aimed at incentivising the migration towards clean technologies have already been witnessed in various MS, through a reduction of the track access charges (TAC), paid by RU to IM, related to the adoption of innovative and environmentally friendly the rolling stock.

As for the retrofitting of the rolling stock fleet to hasten the migration towards innovative technologies, two issues arise: first, some of the technologies considered are still at a prototype stage of development, thus there is no industrial production and information on the costs for the retrofitting is not available to rolling stock owners; second, for the technologies that could be retrofitted, it has emerged from the tailored interviews that it is not considered a feasible practice by stakeholders. Representatives from EU JU, UNIFE and ERFA have highlighted that retrofitting is often hindered by high costs related to the actions that are necessary to retrofit the rolling stock. Indeed, retrofitting a specific piece of rolling stock requires the development of a prototype for the implementation of the technology into that piece (the prototype would be needed to understand the structural changes that are needed to implement the new technology, such as which parts need to be moved or removed and where to install the new equipment, for instance, removing the mechanical coupler and installing the digital one); once the prototype has been developed, there are recurring costs to be incurred for the actual retrofitting operations of each piece of rolling stock.[200] The cost of the prototype, which can be of several millions, can be spread across all the pieces of rolling stock of the same type, but the definition of "type" of rolling stock is narrower than the simple distinction between freight wagons, passenger and tractive rolling stock, as it needs to take into account all the elements that differentiate two pieces of the same kind of rolling stock (e.g., internal design differences between two locomotives). Overall, these costs

[198] The stakeholders' survey included a question on the part of the costs of implementing different technologies that was due to interoperability. No answer to the question has been received.
[199] Nexrail Lease Sarl from Netherland, and Sandahls Equipment AB and Nordic Re-Finance AB from Sweden.
[200] See European Commission "Decision authorising the use of unit contributions to support the deployment of ertms, electric vehicles recharging infrastructure and the retrofitting of noisy wagons under the connecting europe facility (CEF) – transport sector", available here.

are sometimes even higher than the value of the rolling stock that needs to be retrofitted. This means that, unless subsidised, RU would thus have the incentive to acquire new rolling stock which is already equipped with the new technology, when the old one needs to be replaced.

More broadly, there are some factors that hinder the adoption of new technologies in general and are not limited to retrofitting (although they also affect the incentives to retrofit the rolling stock). As RU are not always the ones reaping the benefits of new technologies (for instance migrating to the Future Railways Mobile Communication System would mostly benefits IM), RU have little incentives to migrate towards new technologies. A representative from one of the main associations representing vehicle owners has also highlighted that a perceived risk is that the new technology will become obsolete in just a few years, making the retrofitting investment not worth it, as there would be not enough time to recoup it. The available evidence suggests that the high costs can slow the migration towards innovative technologies until the investment becomes mandatory, or rolling stock has to be replaced in any case because it has reached the end of its useful life, and therefore the cost of migrating toward a new technology is lower.

The following presents a summary of the information collected by the Consortium on relevant new technologies – such as the Future Railways Mobile Communication System (FRMCS), digital automated coupling (DAC), Virtual Coupling (VC), Automatic Train Operation (ATO) over ETCS, and Predictive Maintenance (PdM) – on clean technologies, namely Fuel Cell and Hydrogen (FCH) and electric traction (catenary and battery). Each of the Sections on new and clean technologies concludes with an analysis of the incentives of the relevant stakeholder to migrate toward the technology analysed.

3.5.1 Future Railways Mobile Communication System

Future Railways Mobile Communication System is a new communication standard – currently under development under the supervision of the UIC – to enable communication between different rolling stock and between rolling stock and trackside infrastructure (e.g. stations and eurobalises)[201] to be transmitted on 5G networks, ensuring a lower latency and overall higher reliability than the currently used Global System for Mobile communications for Railways (GSM-R), which is a communication standard based on 2G digital cellular networks.

The use of GSM-R is currently mandated by TSI,[202] but it is expected to become obsolete and thus not supported by mobile operators starting around 2030. Systra (2015) reports that while it is expected that TSI will be updated to reflect the need for a new mandatory standard, according to Art. 5(2) of the original TSI[203] the infrastructure and any functional part of the rolling stock (e.g., the on-board command control) need to comply only with the standard existing at the time of their placing into service (i.e. when the rolling stock is first authorised to operate in Europe) and would retain their compliance status, meaning that old systems do not have to comply with updated standards and multiple technologies could be allowed coexist on the market. Nevertheless, during the interview, a representative from ERA has explained that the authorisation to operate on the railway network has to be renewed every 5 years; while updated TSI will allow for a transition period for rolling stock to be retrofitted, at the time of renewal of the authorisation rolling must comply with the current TSIs.

UNIFE (2021) identifies some of the risks related to the migration to FRMCS. These are the limited availability of spectrum, which might not be sufficient for all the uses envisioned by UIC, the increased risks in terms of cybersecurity as a higher volume of increasingly complex data will be shared on a relatively new system, as well as the interoperability of the new standard with standards used in other countries outside the

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[201] The eurobalise is a transponder placed between railway tracks. It serves to collect and transmit information on the location and direction of the train.
[202] The TSI define the operational and technical standards that structural and functional parts of the EU railway system must comply with to ensure interoperability within the EU.
[203] EUR-Lex - 32008L0057 - EN - EUR-Lex (europa.eu).

EU. This last point seems to be particularly relevant considering that while the UNIFE (2021) roadmap for Europe estimates a general deployment of FRMCS from 2028 onward, countries like Korea, Australia, India and Russia are considering an early implementation of the FRMCS (as early as 2025) based on 4G standards rather than 5G like in the EU, increasing the costs related to the interoperability with the European infrastructure. Moreover, as currently only early-stage prototypes for 5G FRMCS exist, unforeseeable difficulties might arise in the future; indeed, early-stage prototypes serve to demonstrate the feasibility of a technology and usually differ from the final product in terms of technical characteristics and design.

The main bottleneck to the migration towards the new communication system, according to Systra (2015), is the lack of a legal requirement to upgrade the existing equipment, which creates a misalignment of incentives between RU and IM. Indeed, once GSM-R will stop being supported by mobile network operators, IM will have to continue supporting this communication standard to ensure the continuity of communication functionalities, and the related cost can be reasonably expected to increase sharply; thus, IM have the incentive to migrate toward the FRMCS before 2030 to avoid such high costs. On the contrary, RU contacted by Systra (2015) have expressed no interest in rushing the migration to the next generation; indeed, a longer migration period would be preferred, as it would allow to replace the rolling stock and handheld devices at, or closer to, their end of life, so that it would be possible to avoid the expenditure due to the upgrade of equipment that would need to be replaced in a few years. Indeed, these costs do not seem to be low: a railway undertaking (the only respondent to this specific question of the stakeholder survey) has stated that implementing this technology required an investment of approximately €280,000 per locomotive.

An expert from EU JU interviewed for the study has also highlighted that this misalignment is not the only bottleneck hindering the migration; indeed, while a subsidy to RU who start the migration to the FRMCS could be a solution, there is also a need to develop a coordinated migration plan at a European level. Without a concerted effort to ensure that all MS migrate at the same time, there is the concrete risk that a mixture of communication systems, based on 2G and 5G standards, would exist in the EU, leading to a considerable reduction in the interoperability of rolling stock within the EU.

However, given the approaching obsolescence of GSM- and the fact that FRMCS is instrumental to the adoption of other innovative solutions, that hinge on the reliability and speed that it can provide. Indeed, according to UIC (2020), FRMCS is pivotal for the implementation of, *inter alia,* solutions such as automatic train operations (a claim that has also been made by CER in a position paper sent to the EC in 2020) and VC, to incentivise the development of these technological solutions, subsidies aimed at incentivising the migration to FRMCS would be advisable.

3.5.2 Digital Automated Coupling

DAC is a technology that automatises the coupling process and the other tasks that are necessary for freight train assembly, such as the recording of wagons' data, checking brake functionality and inspecting the wagons, leading to a reduction of shunting times and an increase of network capacity and wagons' productivity. While Automated Coupling systems are used around the world to couple freight wagons and locomotives, European countries still rely on screw coupling systems and on the manual performance of all the other tasks by the staff employed by RU.

Pollen et al. (2021) estimate that, in Germany, shunting operations require approximately 170 minutes to be completed, when performed manually, whereas with full automation these would require approximately 65 minutes. The long times needed for manual shunting renders the whole process particularly onerous for RU in Europe, in light of the low average distance travelled by freight trains (253km in 2015, according to Gesellschaft für Transport-und Unternehmensberatung mbH, 2020). The reduction of shunting times would allow not only to reduce the costs of rail freight transport, but also to increase the length of trains (which is currently constrained by both the already long time needed to manually perform all the tasks that are accessory to the shunting of trains,[204] and by the characteristics of the railway network, which does not allow for longer trains[205]) and increase the productivity of freight wagons, as the same wagon can transport more goods over the same period.

Gesellschaft für Transport-und Unternehmensberatung mbH (2020) estimates the total cost of EU-wide (plus UK, Switzerland and Norway) migration to DAC to be between €6.4 and €8.6 billion. The estimated benefits from the migration to DAC would be on average €760M per year, deriving mostly from the reduced assembling times (including brake tests), which would lead to an increase in the capacity of shunting and marshalling yards, and the increased trains' weight made possible by the higher strength of automatic couplings. These enhancements would lead to an increased wagons' productivity and overall network capacity.[206] Another estimate of the costs for the migration to DAC has been provided by UIP, which has indicated that retrofitting a freight wagon would cost around €25,000, whereas the cost for a locomotive would be around €50,000.

Wagons using screw coupling and wagons with DAC systems are not natively compatible with one another and can only be operated together using an adapter physically installed on the DAC or a buffer wagon with hybrid couplings. This is likely to lead to higher costs, compared to operating single-system trains, due to the use of the buffer wagon, which cannot be coupled automatically. This limitation is one of the main barriers to the implementation of DAC: according to Gesellschaft für Transport-und Unternehmensberatung mbH (2020), the migration needs to be coordinated at the EU-level, as the benefits of DAC are highly dependent on the share of upgraded wagons that can be natively coupled with one another. Indeed, around 80% of the existing freight wagons in Europe belong to signatories of the General Contract of Use for Wagons (GCU) and are enlisted for mutual exchange between RU; this means that freight wagons belonging to the signatories end up forming trains with wagons of different RU.[207] Hence, there is an issue of EU-wide coordination related to the upgrade of the rolling stock. Indeed, a RU would have the incentive to wait until other operators have converted their fleet, in order to reap the full benefits of migrating to the new system. On this matter, the EU JU has pointed out that a subsidy to first movers could incentivise the migration; nonetheless, in order to ensure that these RU have the incentive to begin the migration, the subsidy should be high enough so that the RU are not making a loss from the early migration during the ramp-up phase.

Moreover, Gesellschaft für Transport-und Unternehmensberatung mbH (2020) identifies another issue related to the EU-wide migration, which is given by the limited production capacity of coupling manufacturers. This limitation creates a bottleneck that might potentially lead to different incentives across RU: on the one hand, incumbents with larger fleet would have the incentive to wait to upgrade to minimize the need to use buffer wagons; on the other, entrants, who own smaller fleets, could potentially complete the migration to DAC in a relatively short amount of time, thus reducing to a minimum the need to operate two different coupling systems at the same time. This would reinforce the coordination problem mentioned above, as entrants' fleets would not be interoperable with incumbents' fleets, as well as lead to a need for a higher subsidy to first movers, as the migration period could end up being longer than planned due to capacity constraints. Thus, it seems unavoidable that there will be a time during which different coupling systems will need to coexist.

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[204] The marshalling personnel might have to walk the full length of the train even six times according to Gesellschaft für Transport-und Unternehmensberatung mbH, 2020.

[205] For instance, passing sidings are usually not long enough to allow for longer trains.

[206] It should be noted that these benefits are not expected to be realised uniformly over the migration period; instead, four phases can be distinguished: (1) few wagons are equipped with DAC and operate on specific routes, reducing shunting times and producing major benefits; (2) additional costs will be incurred for the parallel operation of wagons equipped with DAC and screw coupling; (3) as the number of wagons equipped with DAC becomes the majority, the benefits additional retrofitted wagons increase significantly; and (4) only older and residual wagons will be retrofitted.

[207] The GCU specifies the mutual rights and obligations of Wagon Keepers and RU with regard to the use of rail freight wagons as a means of transport throughout Europe and beyond. GCU – Bureau (gcubureau.org).

3.5.3 Virtual Coupling

VC is a concept envisaging the automated, interconnected control of trains, so that these would move synchronously, leading to a minimisation of the admissible distance between two successive trains on the same route which would allow to increase trains' departure frequency and ultimately their productivity as well as the overall network capacity.

Because of the shorter distance between trains, reaction times of human drivers would no longer ensure safety, thus ATO is needed for the automatic and timely transmission of relevant information to other trains and, ultimately, safety. Nonetheless, ATO equipment is only a marginal part of the investment needed to migrate towards VC. Indeed, according to the expert interviewed by Quaglietta et al. (2018), the investment would also need to cover: (i) installation of new trackside equipment and removal of previous signalling system; (2) installation of ATO equipment on the entire fleet; (3) installation of Train Integrity Monitoring (TIM)[208] on board of the train fleet; (4) installation of the vehicle-to-vehicle (V2V) communication systems; (5) update of the software/hardware of the on-board computers; and (6) update of the power supply system. Table 12 below reports the average investment, estimated by Quaglietta et al. (2018), that would be needed to migrate from either the 3-aspect[209] or the ETCS L2 to VC on a railway line. A further investment, estimated to be approximately €330 million, would be needed to obtain the necessary authorisations.

Table 12: CAPEX for migration to VC

Cost item	Signalling system	
	3-aspect to vc	L2 to vc
Trackside design and equipment installation	€1,100,000/km	-
Train equipment and installation	€615,000/mu	-
Tim equipment	€24,000/mu	€24,000/mu
Recovery of unwanted train detection and signage	-	€100,000/km
Software upgrade	€50,000/mu	€100,000/mu
Ato equipment and installation	€240,000/mu	€240,000/mu
V2v communication equipment	€20,000/mu	€20,000/mu

Source : Shift2Rail (2018).

The main benefits of VC would be observed in the freight transport segment. Indeed, migration to VC would allow to increase the frequency of departures and thus the total freight that it is possible to move. Indeed, Quaglietta et al. (2018), assuming a 20% increase in the fee charged to customers (which would cover the costs related to the higher frequency and flexibility of the offer), estimates, from survey answers, "that 46.6% of truck users would shift to freight trains" which implies that, according to their study, the rail modal share would grow from around 20% to 60%. According to Aoun et al. (2020), this is due to the fact that customers perceive rail transport as more reliable, and the greater flexibility and capacity that would derive from the implementation of VC would be appealing. For the passenger transport market, instead, the increase in price

[208] TIM systems monitor and report the length and status of trains.
[209] The 3-aspect is a coloured light signalling system. A red light indicates that the next section contains a train, a yellow one indicates that the section is clear but the following one is not, and a green indicates that both sections are clear.

due to the higher frequency estimated by Quaglietta et al. (2018) would lead to a reduction in the modal share in every segment except the regional one.

While VC seems apt to promote the modal shift, at least for the freight market, similarly to DAC there is still a problem of coordination. Indeed, a RU may have the incentive to wait that other operators have migrated to VC as well, to reap all the benefits of the technology; if only a small subset of trains is equipped with VC, the its benefits can only be reaped if two (or more) successive trains are equipped with it, and only by the second train (as the first would still be bounded by another train without VC). Thus, benefits for the adoption of VC depend on how many RU have migrated to this technology, meaning that the incentives for first movers will be quite small, and subsidies might be advisable.

Moreover, VC would need to rely on FRMCS to ensure that ATO are possible. Relatedly, Quaglietta et al. (2018) asked experts to indicate their main concerns and the likelihood that these could be solved within five years; the experts indicated that they do not expect safety-concerns and the reliability of the communication system to be sufficiently addressed within five years. Moreover, a representative from UIP has highlighted that, as VC relies on ATO and FRMCS, coordination at the European level is also needed to ensure that rolling stock using VC and the national networks are interoperable.

3.5.4 Automatic Train Operation over ETCS

Automatic Train Operation (ATO) is a technology which enables automatic real-time decisions of trains' operations, which allows to optimize acceleration, braking and coasting (Yin et al., 2017). ATO does not simply allow to run the train at the highest speed possible, but actively develops a driving strategy, which allows to maximize the use of the network capacity (particularly in congested areas) and to reduce the energy expenditure (Emery, 2017) Four grades of automation (GoA) are envisaged in the industry, each characterized by a different level of automation. Table 13 below describes which operations are automated, and which still require a driver, at each grade of automation.

Table 13: Grades of automation

Grade of automation	Door closure	Setting train in motion	Stopping train	Operation in case of disruption
GoA 1: Non-automated train operation	Driver	Driver	Driver	Driver
GoA 2: Semi-automated train operation	Driver	Automatic	Automatic	Driver
GoA 3: Driverless train operation	Attendant	Automatic	Automatic	Attendant
GoA 4: Unattended train operation	Automatic	Automatic	Automatic	Automatic

Source: ASTRAIL 2018.

ATO is widely used across countries in urban settings. Indeed, the Paris Métro, London Underground, Beijing Subway, Tokyo Metro (Yin et al., 2017) and the Rome Metro[210] all rely on this technology, at least on some of their lines, but today this technology is not employed on national railway networks (Emery, 2017). This is possible due to the comparatively lower number of factors that affect urban railway traffic. Indeed, in order to properly function, ATO requires a stream of detailed, up-to-date information, which are

[210] See Metro C | Roma Mobilità.

provided to it by the Automatic Train Protection (ATP) equipment installed both on the rolling stock and on the trackside (e.g., it needs to collect information on the train speed, the closest trains, the distance to the closest station for coasting operations etc). On the European railway network, it is the European Train Control System (ETCS), which is the signalling and control part of the ERTMS, which offers standardized ATP functions.[211]

The ETCS aims at replacing the legacy signalling systems that are active in the different MS. Currently, three levels of the ETCS are envisaged:

- level 1: it involves a continuous supervision of the movement of the rolling stock by the onboard software, based on an exchange of information between the train and trackside equipment. Fixed signalling (such as 3-aspects, see footnote 209) is still required;
- level 2: upgrading from the level 1, information is continuously exchanged between the rolling stock and a Radio Block Centre (currently via GSM-R), which allows to continuously compute the position and the speed of the train. Eurobalises are used as milestones to check the accuracy of the data; and
- level 3: upgrading from level 2, information is continuously exchanged between each train and the central control, without requiring any trackside equipment other than eurobalises. This means that information on the position and speed are based on the information directly provided by the onboard equipment, rather than requiring the intermediation of the Radio Block Centre. This also allows trains to reduce the distance to a level much close to absolute braking distance, and thus the implementation of moving blocks (see section 3.5.3 on virtual coupling).

Currently, the deployment of ETCS, being part of the ERTMS, suffers from the same shortcomings. While there is a target of 49,000km of ETCS being deployed by 2030, as of September 2019 only 5,733km were installed.[212] The slow deployment of ERTMS is partially due to the high costs related to the retrofitting of existing rolling stock with the system. According to the data available from multiple retrofitting projects funded by the Connecting Europe Facility (CEF),[213] data provided by one of the main association representing vehicle owners, and a State aid decision for Denmark (case SA.57809),[214] both the recurring and non-recurring (i.e., the development of a prototype) costs of retrofitting are particularly high: the costs related to the development of a prototype show a high degree of heterogeneity between different types of locomotives, going from €1.3M up to €15.5M; recurring costs also show a certain degree of variation, although a lower one, ranging from €250,000 to €670,000. These broad ranges can be explained by the mechanical differences of locomotives, which are also influenced by whether the rolling stock is authorized to circulate in more than one MS (and thus might already have multiple signalling and communication systems that need to be removed or adapted).

While the installation of ERTMS on-board equipment is not strictly required for ATO, the development of the trackside infrastructure is strictly linked to the deployment of on-board equipment.

The slow deployment of ETCS[215] is only one of the two bottlenecks that hinder the migration towards ATO on the main railway lines. Indeed, outside of the controlled urban environment, the implementation of ATO is much more complicated; Yin et al., (2017) describes thoroughly all the real-time information that the ATO framework needs to collect and manage: the traffic control system collects information on disruptions, deviations and conflicts, in order to allow the development of a new train scheduling plan; this is based on data from the rail transport plan (such as the pre-existing schedule) and real-time information (such as train position and speed) for all the trains in the

[211] See UNIFE, "Pioneering ATO over ETCS level 2", available here.
[212] See IRJ "Will ERTMS ever reach critical mass in Europe", available here.
[213] See footnote 200, and CEF projects 2016-BE-TM-0297-W, 2017-IT-TM-0003-W, 2014-LU-TM-0410-W, 2015-CZ-TM-0295-W.
[214] See SA.57809 https://ec.europa.eu/competition/state_aid/cases1/202040/287586_2192023_59_2.pdf
[215] See "European Train Control System": https://www.trackopedia.info/encyclopedia/infrastructure/european-train-control-system-etcs.

system. Once this information has been collected and analysed, the updated schedule is sent to the train's ATO system, which collects information on local data (such as weather, train speed) and develops a new optimal driving strategy, which then informs the traffic control system. It is, in practice, a loop of continuous data collection and analysis. Given the amount of information and the complexity of the variables involved, complex algorithms are required, to allow the system of equations that can describe the reality to be optimized, subject to all the constraints imposed (such as the need to reduce delays to a minimum, a change of speed that does not influences passengers' experience etc). Indeed, both Yin et al., (2017) and ASTRAIL (2018) report that a number of algorithms already exist and other are being developed, but there does not seem to be a "one-size-fits-all" solution, given the complexity of the problem. The second bottleneck in the deployment of ATO on the European railway network is thus the development of fast and reliable optimization solutions.

Nonetheless, it seems that some prototypes have been currently implemented. For instance, Shift2Rail, in a presentation of 2021,[216] reports a number of successful attempts at implementing ATO, although they are all based on at least ETCS level 2.

As for other technologies, there seems to be diverging incentives between RU and IM for the deployment of the needed technology that would allow ATO over ETCS to work. Indeed, national IM have already invested in the legacy train control systems and, as shown by the low penetration of ERTMS and thus ETCS, have little incentive to undertake the necessary investment to actually implement ETCS level 2 or above on national railway networks. Moreover, in a position paper sent to the EC, CER has claimed that to ensure the interoperability of ATO, FRMCS should first be fully standardized at the European level, as its functionalities are needed for ATO. On the other hand, RU might have the incentive to migrate towards ATO, not only because it can ensure faster and more reliable journeys, thus potentially increasing the productivity of rolling stock and partially countering the issues caused by the congested network, but also because it can reduce energy consumption by 5-15%, as shown by González-Gil et al. (2014). If one wanted to promote the development of ATO, a European-wide coordination, as well as incentives to IM to hasten the migration towards ETCS might be a way to do so.

3.5.5 Predictive Maintenance

PdM is based on advanced methods, such as machine learning, which allow to predict when a specific component will need to be maintained before it actually breaks. This approach allows to extend the useful life of an asset, enhance the management of spare parts (particularly of legacy parts), reduce maintenance times and minimize unplanned downtime, leading to an overall higher capacity utilisation of the existing fleet (Lugara, 2018).

Currently, RU rely predominantly on preventive maintenance, i.e. the rolling stock is maintained once certain thresholds based on time or distance (usually set by regulators) are reached, and reactive maintenance, i.e. the equipment is repaired or substituted once it gets worn out or damaged (Wippel et al., 2021). Yet, this approach is inefficient and involves high costs; indeed, train fleets typically need an operational reserve between 5% to 15% as back-up in case of failure (Lugara, 2018), and according to Stern et al. (2017) around 30% of the time that rolling stock spends in maintenance is taken up by manual failure diagnostics. Moreover, legacy spare parts might not be readily available, which would increase the maintenance time (Wippel et al., 2021).

PdM involves installing sensors on trains' subsystems, collecting information on the status of the assets and communicate this to control rooms, where the data is then integrated with other data (e.g., weather conditions) to constantly predict the risk that a piece of equipment will deteriorate and cause a halt to the train's operations. Through PdM, it is possible to reduce the unnecessary maintenance, to avoid that upkeep is carried out too late, and to ensure that replacement parts are readily available.

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[216] See Shift2Rail "ATO over ETCS – an interoperable journey", available here.

While Predictive Maintenance could increase the useful life of assets and increase the reliability of railway transport mitigating the risks of serious outages, its use might be limited. Indeed, according to Lugara (2018), it is crucial to define a narrow selection of subsystems and events that need to be predicted through the algorithm, as trying to predict all possible scenarios would lead to misleading results and wasting of resources.

An alternative to PdM could be Condition-based maintenance (CbM). Stern et al. (2017) estimates that CbM, which is performed based on the condition of the vehicle as assessed by the sensors (Roland Berger, 2016), could lead to an overall reduction of maintenance costs of at least 10% to 15%. Unlike PdM, CbM does not require to collect data on all the factors that can influence a specific component, such as weather and the power flow on the track. According to Stern et al. (2017), once CbM is implemented, migrating to PdM would provide only small incremental returns.

Regardless of the specific maintenance regime implemented, RU would still need to install and operate sensors on multiple components. A precise estimate of these costs is complex: while no precise estimate is provided, the related costs are considered to be high in the literature (Stern et al., 2017 and Kalathas and Papoutsidaki, 2021) whereas responses to the survey have highlighted a high level of heterogeneity.[217] Moreover, according to a representative from UIP, PdM cannot be installed on rolling stock pieces which do not have a technological solution (such as DAC) which allows the single railcar to provide electricity to the component.

Another issue with the migration to this technology is that, following the implementation of the new maintenance regime, the intervals between maintenance cycles, being based on real conditions data rather than regulatory thresholds, could increase and maintenance could become less frequent than what envisaged by regulators, thus requiring an adjustment of the current regulatory frameworks (Roland Berger, 2016).

Finally, although it requires less data than PdM, CbM still requires high amount of data to be collected, stored and elaborated. This creates once again a problem of coordination in the market; as the data collected by a single RU would not be sufficient to ensure the prediction of possible failures and the effects of maintenance cycles on restoring worn out parts, RU would need to share data on their locomotives and wagons (Roland Berger, 2016). Thus, each RU would have the incentive to wait and see whether others have implemented PdM, so that they can collect the needed data, and whether they have decided to share it with other operators.

3.5.6 Fuel Cell and Hydrogen

Fuel Cell and Hydrogen (FCH) is a clean propulsion technology that can be used in the rail sector as a substitute for the incumbent diesel engines. A fuel cell is an electrochemical cell that converts the energy of a fuel into electricity. Electric batteries are an example of electrochemical cells, but do not require a fuel.

FCH technologies have been trialled in the rail sector since at least 2001 (Guerra et al., 2021), mostly for shunting locomotives. Nonetheless, FCH can be applied to any type of railway transport; indeed, Ruf et al. (2019a) report that this type of propulsion technology makes the most economic sense when seeking to reduce emissions on non-electrified low-traffic routes of at least 100km, or in marshalling yards, which is in line with what has been reported by Hydrogen Council (2020). The competitiveness of hydrogen on these routes is due to the high infrastructure costs related to the construction of the electric catenary infrastructure (between €1M to €2M per km of track) and the fact that electric batteries would not provide enough power for such long trips. Moreover, FCH can be refuelled much faster than electric batteries, requiring up to 20 minutes to ensure an operativity of around 18 hours (Guerra et al., 2021).

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[217] The answers provided indicated tha the cost of upgrading a freight wagon is more than €500,000, the costs of upgrading a locomotive is approximately €3,000 and the cost for upgrading wagons and locomotives ranges between €51,000 and €115,000, indicating (somewhat counterintuitively) that the cost of PdM for locomotives is lower than that of wagons. It should be noted that only 4 stakeholders provided responses to the relevant question; thus, the extent to which these estimates can be generalised is unclear.

Ruf et al. (2019b) estimate the costs related to the acquisition of new/retrofitted FCH-propelled units, and the costs for operating these trains. Nine case studies are proposed, covering multiple units, shunting locomotives, and mainline locomotives. On average, new FCH units cost 64% more than diesel ones, with mainline locomotives being the most expensive due to the need for higher traction power needed to move freight and passenger wagons. Retrofitting existing units to FCH costs on average 33% more than the investment needed for new diesel units. Nonetheless, the higher investment cost can be partially offset by the lower maintenance costs of fuel cells compared to diesel engines, which are on average 23% lower; this is due to the fact that FCH do not have moving parts, unlike diesel engines, and can avoid many of the issues caused by internal combustion, such as smaller components breaking down. Indeed, FCH degrade slowly over time, and can operate up to 30,000 hours (Ruf et al., 2019c), which is approximately equal to 9 years if operating for 9 hours a day, every day.

Although FCH present many advantages compared to electric catenary, electric batteries and diesel engines, adopting this propulsion system is not straightforward. Indeed, the incentives of IM and RU are misaligned; IM would need to sustain high investment costs to install refuelling stations along the network. Moreover, before FCH can move from the trialling stage, interoperability with the existing infrastructure must be ensured. Indeed, the presence of a hydrogen tank can create multiple problems; for instance, if installed on the roof of multiple units, it must be ensured that the height of tunnels is sufficient and that there is no risk of a contact with existing catenary lines. More generally, as hydrogen is a flammable gas, investments would be needed to install hydrogen sensors and gas extraction systems in tunnels, workshops, and enclosed stations, and to ensure enough ventilation in case of leaks. Essentially, any area in which hydrogen could become entrapped and ignite would need to be examined (Ruf et al., 2019b). Thus, IM and private service providers (such as maintenance workshops) would need to sustain high cost without any marginal gain; on the contrary, RU would have the incentive to migrate as fuel and maintenance costs are lower and could counterbalance the higher investment needed to acquire or retrofit existing units.

3.5.7 Electric catenary and batteries

Railroad electrification via catenary is widespread in Europe, with around 56% of the total network length for the EU-27 being equipped by overhead lines in 2019 (Transport Statistical Pocketbook, 2021). Nonetheless, there is a high degree of heterogeneity both across different countries, with Western Europe showing higher level of overhead coverage, and within countries, with some infrastructure such as stations and intermodal terminals not always being electrified.

The impossibility of relying on overhead traction is one of the reasons why diesel engines are still used today. Zenith et al. (2020) compare the investment and operating costs of diesel locomotives and, *inter alia,* electric overhead traction and battery electric locomotives on two specific routes located in the United States and in Norway.[218] They estimate the Equivalent Annual Cost (EAC)[219] of different cost items, namely the CAPEX and OPEX[220] for infrastructure, energy (storage and consumption) and locomotives.[221] Based on their estimates for 2020,[222] the investment needed to acquire new electric locomotives (either catenary or battery) in Norway is around 21% lower than the one needed for diesel locomotives, whereas in the US it is around 35% higher, but this is partially due to the need to transport higher volumes of freight and thus to use a stronger engine (indeed, the METRANS Hub in Prague's management, interviewed for

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[218] While these two countries are not part of the EU and their rail freight transport sector is different from the European one, the study can still provide some insight on the costs related to the investment and operation of clean technologies.
[219] See Annex 11.1.
[220] The Capital Expenditure (CAPEX) and Operating Expenditures (OPEX).
[221] The CAPEX for energy includes the investment needed to acquire the buffer wagons to transport electric batteries, while the OPEX for locomotives includes a tax on diesel locomotives in Norway.
[222] Note that the estimates are reported only in graphical form (figure 3), and values have been extracted from the figure. Hence, the figures provided in the main text of this report should be considered as approximations.

one of the case studies – see Annex 16 – has pointed out that electric engines can be used to propel much heavier trains than diesel engines). Costs increase sharply if one includes the investment needed for the buffer wagons and the batteries, with the investment needed in Norway being more than 10 times higher than for diesel locomotives.

Results on operating expenses are also somewhat mixed: while compared to diesel the average maintenance costs for electric propulsion locomotives is around 60% lower, in the US only maintenance for electric catenary is lower (-40%), whereas for electric batteries it is slightly higher (12%). The higher maintenance price for electric battery powered rolling stock is due to the need to transport higher volumes and for longer distances in the US, thus needing more batteries.[223]

Responses provided by RU to the survey confirmed that the CAPEX for electric locomotives is higher than that of diesel locomotives, while the OPEX is lower for electric locomotives (with savings ranging from 15% to 55% approximatively) More specifically, freight operators have indicated a higher differential CAPEX than passenger operators, although this evidence is limited to only one passenger undertaking and three freight undertakings.[224]

Overall, when considering all the investment and operating expenses (including those related to the infrastructure, such as the construction of overhead lines or charging stations), Zenith et al. (2020) estimate that in Norway the payback period (i.e., the amount of time needed before the investment made is equal to the savings from not using diesel) for electric battery is around 3.1 years, whereas overhead traction would never be cost efficient. In the US, on the contrary, overhead traction would be the only cost-saving technology, although on a longer period (around 11.4 years). Nonetheless, these estimates do not consider the external costs related to CO^2 and other emissions, which according to Popovich et al. (2021) can represent a sizeable share of the costs related to diesel locomotives in the US, whereas the share of these costs for battery electric engine is around half.

IM and RU have opposite incentives to invest in these technologies. On the one hand, IM would need to sustain high investment costs to install overhead catenary lines and recharging stations, and the maintenance costs for catenary lines is particularly burdensome; moreover, operators of complementary services (such as intermodal terminals) would also need to invest in the infrastructure to ensure that the interoperability of the rolling stock with their infrastructure. A representative from UIP has also highlighted that, since most of the traffic occurs on the electrified part of the network, IM have little incentive to electrify the remaining part, as they would bear high costs but reap virtually no benefits. RU, on the other hand, would have the incentive to switch for two reasons:

- First, operating costs (i.e., maintenance and in particular fuel) are lower than diesel engines', which would reduce the overall costs over the lifetime of the rolling stock;
- Second, electric traction can be used to move heavier trains, thus increasing the productivity of the rolling stock.

CONCLUSIONS:

Despite the long-term efficiency benefits of new and clean technologies, RU might have the incentive to delay migration towards these technologies until their rolling stock has reached the end of its life and should be replaced anyway, because being equipped with these technologies will bring benefits only to the extent that they are introduced at a certain scale. Moreover, the incentives of RU and IM are often misaligned, as the migration to certain technologies requires high investment from IM, with little to no benefit for them to reap. To foster the adoption of these technologies, it might be desirable to provide EU-wide coordination. Subsidies to first movers might also be warranted.

[223] Contrary to what Zenith et. al (2020) report, METRANS' management has pointed out that both the investment and the maintenance costs for electric locomotives are higher than diesel locomotives.
[224] One responded also indicated that the CAPEX for electric locomotives is lower than that of diesel's, although this is considered to be a typo as the responded indicated that the CAPEX would be [90-100]% lower

3.6 State aid for rolling stock

Within the state support measures database, the Consortium identified 20 investment aid state support schemes[225] relating to the acquisition and retrofit of rolling stock in the rail and inland waterway industries.

These schemes made up 19.23% (20/104) of the decisions in database. The total budget for rolling stock measures over the period was approximately €1.40 billion with a budget of €28.51 million in 2012 and €222.91 million in 2021. In addition to these 20 investment aid schemes there is some evidence that operating aid schemes can be used to incentivize retrofit of rolling stock, this is discussed in subsection 3.6.2.2.

3.6.1 Interoperability

We only identified four MS (namely Czech Republic, Denmark, Germany, and the Netherlands) which ran state support schemes specifically focused on interoperability. We located ex post analysis on 3 of the 4 schemes (namely the schemes in Czech Republic, Denmark, and the Netherlands). The total budget for the measures over the period was at least €44.17 million with a budget of €5.71 million in 2012 and €6.60 million in 2021.[226]

The Czech scheme, 'interoperability in rail transport' was initially approved in 2008 in case N/469/2008[227], and renewed in 2012 under State aid decision SA.35948[228] and again in 2014 under SA.38115[229] it functions by offering direct grants to railway undertakings to gradually improve the technical and operational interconnection of railway systems in order to become compliant with TSI-TAF, the scheme initially had a budget of approximately 40 million euros and an aid intensity of 50%. The budget was unaltered throughout the scheme, although the scheme was extended twice due to delays in the approval of aid requests in 2012, and an additional call of interest, finalised in 2015.

In 2017, Denmark notified the commission of an ERTMS development scheme under SA.38283[230], it renewed this scheme in 2020 under SA.57809[231]. The scheme aims to replace all Danish ATC (Automatic Train Control) with ERTMS between 2018-2023. The aid took the form of direct grants, the scheme initially had a total budget of approximately 7.37 million[232], the scheme aimed to distribute total available funds between applicants rather than award aid at a particular level although capped aid at a 50% aid intensity and a maximum compensation of approx. €161,000 per unit for the first freight locomotive in a series of locomotives equipped with an ERTMS-system and €67,000 per unit for following freight locomotives in the same series.

However, by June 2020, the scheme had received 0 aid applications. In SA.57809 it was estimated that the market prices for purchase and upgrade of ERTMS equipment were 2-2.5 times higher than the per locomotive aid ceilings in SA.38283 implying that under the existing aid ceilings per locomotive, aid could only cover around 20%-25% of the equipment's market price. The 2020 decision removed the aid limit per locomotive and extended the deadline for applications to 2030.

In 2019, the Netherlands notified the commission of a support scheme for ERTMS upgrades under SA.55451[233]. ERTMS in the Netherlands is co-funded by European funds under connecting Europe facility (CEF) funding, these grants covered €23,814,758 of

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[225] Note that all state aid measures in this section are schemes, as opposed to the measures in section 4 *'state aid for infrastructure'* which contains a mix of schemes and individual aid decisions.
[226] Note that it was only possible to identify budgeted figures for three of the four schemes, as there was no available data on the German Scheme.
[227] See 2009/C 53/01 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52009XC0306(01)&from=EN
[228] See SA.35948 https://ec.europa.eu/competition/state_aid/cases/247158/247158_1468536_73_2.pdf.
[229] See SA.38115 https://ec.europa.eu/competition/state_aid/cases/251368/251368_1659500_231_2.pdf.
[230] See SA.38283 https://ec.europa.eu/competition/state_aid/cases/259624/259624_2028400_187_2.pdf.
[231] See SA.57809 https://ec.europa.eu/competition/state_aid/cases1/202040/287586_2192023_59_2.pdf.
[232] Exchange rate of 7.4593 applied see ECB reference exchange rate, Danish krone/Euro, 2:15 pm (C.E.T.) - Quick View - ECB Statistical Data Warehouse (europa.eu).
[233] See SA.55451 The Netherlands Support for ERTMS upgrade https://ec.europa.eu/competition/state_aid/cases1/201950/282872_2116868_76_2.pdf.

the €52,921,684 total investment costs (approx. 45%) on 11 freight locomotives and 88 freight vehicles. However, railway vehicle owners refused to accept this level of investment without further national level funding. Therefore, SA.55451 complemented the CEF funding with national level funding of €22,185,242. This suggests an overall average aid intensity of approx. 87%. The State aid decision discusses two aid ceilings:

(i) an aid ceiling of 90% of costs for 'prototyping ERTMS upgrades'
(ii) an aid ceiling of 50% for serial ERTMS upgrades.

These aid ceilings suggest the vast majority of aid awarded under the decision related to prototyping and not for serial roll out of ERTMS systems. It therefore remains unproven if the 50% level of funding will remain sufficient for further investment.

The two ERTMS schemes highlight that the installation and upgrading of interoperability systems is an expensive process that railway stock owners may be unwilling to fund. They echo concerns expressed in a 2017 European Court of Auditors report that infrastructure managers were reluctant to invest in ERTMS technology.[234]

It is therefore possible that the aid ceiling of 50% may be insufficient for the serial upgrading of ERTMS systems. The Danish scheme provides evidence that a funding intensity of 20-25% is, at least under some circumstances, insufficient for any investment, whereas the Dutch scheme provides evidence that funding of 90% can, at least under some circumstances, attract investment.

CONCLUSIONS:

> Four State aid schemes for interoperability were identified, three of which had ex-post analysis. The effects of two schemes (2/3, 66%) were mixed and one scheme was a failure (1/3, 33%). These schemes provide circumstantial evidence that an aid ceiling of 50% may be insufficient for the serial upgrading of ERTMS systems.

3.6.2 Acquisition and retrofit of vessels/rolling stock

3.6.2.1 Acquisition and retrofit of rolling stock in the rail freight industry (omitting interoperability schemes)

Omitting schemes outside the rail freight industry and schemes purely related to interoperability, left 10 schemes concerned with acquisition and retrofit of rolling stock in the industry across 7 MS (namely: Austria, Belgium, Czech Republic, France, Germany, Poland, and Italy). 2 of these schemes related to the acquisition of rolling stock, 5 concerned retrofitting rolling stock. 3 schemes allowed both acquisition and retrofit. The total budget for acquisition and retrofit schemes over the period was at least €749.54 million, with a budget of €20.20 million in 2012 and €187.40 million in 2021.

The two schemes which allowed acquisition but not retrofit of rolling stock were the French Atlantic rail motorway project scheme (SA.38714[235]) and the Czech Aid for intermodal transport units (SA.49153[236]) both of which provided some limited *'ex-post'* analysis.

The Atlantic rail motorway project, aimed to transfer part of the traffic of heavy good vehicles from road to rail between the south of Aquitaine (Bayonne, France) and Nord-Pas-de-Calais (Lille) by construction of a new railway line, the measure included funding for new intermodal units to be used on the line, however the scheme was ultimately cancelled, for a full explanation see Section 2.6.1.1.

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[234] See European Court of Auditors Special Report No 17 (2017) 'A single European rail traffic management system: will the political choice ever become reality? Available at https://op.europa.eu/webpub/eca/special-reports/ertms-rail-13-2017/en/.
[235] 'SA.38714: Investment aid for the Atlantic rail motorway project, available at https://ec.europa.eu/competition/state_aid/cases/252684/252684_1583429_106_2.pdf.
[236] 'SA.49153: Aid for intermodal transport units, available at https://ec.europa.eu/competition/state_aid/cases/271167/271167_1989527_132_3.pdf.

The Czech Aid for intermodal transport units, provides solely for the purchase of intermodal combined intermodal transport units and is the only scheme in this Section which does not concern any other categories of aid. The scheme follows a previous scheme which ran from 2006-2010, the previous scheme was only implemented to a limited extent due to budget constraints.

The new scheme aims to make the purchase costs of intermodal transport units the same as conventional road transport, which the Czech authorities estimated are on average 41.92% higher for intermodal road trailers and 46.3% higher for swap bodies, where the units are used in a continental intermodal transport system.[237] As the entities involved in continental intermodal transport cannot feasibility pass the costs onto consumers as they would not able to compete with road transport, they therefore have no motivation to purchase the units conventionally.

Of the 5 schemes related purely to the retrofit of rolling stock, the majority (4/5, 80%) related solely to noise reduction measures. Noise reduction schemes were introduced in 4 MS: Belgium (SA.60499), Germany (SA.34156, SA.48972, SA.57271[238]), Poland (SA.55443[239]), Italy (SA.51229[240]). The fifth measure related to energy efficiency improvements in Germany (SA.50165[241]). *'Ex-post'* evaluation was publicly available for one of the schemes: the German noise reduction scheme.

The scheme was initially approved in 2012 under SA.34156 and renewed twice. Once in 2017 (SA.48972) and again in 2020 (SA.57271). The scheme is now closed to new applicants. The scheme focused on retrospectively compensating wagon owners with 50% of the costs for retrofitting freight wagons with composite brake blocks.

The scheme aimed to retrofit composite brake blocks to over 80% of the 180,000 freight wagons in Germany, by 2020 this measure was expected to half freight railway noise pollution from 2008 levels.[242] As of July 2020, aid had been requested on 181,014 freight wagons and aid had been granted for 59,527 of these wagons. This suggests that nearly all freight wagons operating in Germany applied for the aid.[243] National level searches suggest that the scheme achieved its objective of halving rail freight noise pollution[244].

Although the Consortium was unable to find the final cost of the scheme, as of May 2020, €27,500,000 of the schemes €152,000,000 total budget had been disbursed. As this equates to approximately 18% of the budget, and aid had been granted to approximately 33% of wagons, it therefore appears likely that the project remained in budget[245].

Although the scheme was successful, it needed to be altered in 2020 due to the COVID-19 pandemic. The amount of aid that is disbursed to beneficiaries yearly depends on the mileage run by retrofitted wagons within the preceding year. The COVID-19 pandemic

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[237] See recital 9, 'SA.49153: Aid for intermodal transport units, available at https://ec.europa.eu/competition/state_aid/cases/271167/271167_1989527_132_3.pdf.

[238] See 'SA.34156: The Funding Guidelines for noise reduction measures on freight wagons', available at https://ec.europa.eu/competition/state_aid/cases/245324/245324_1397247_150_2.pdf See 'SA.48972: Guidelines on noise differentiated access charges to support noise reduction measures', available at https://ec.europa.eu/competition/state_aid/cases/270845/270845_1953877_76_2.pdf. See 'SA.57271 Prolongation of the Funding Guidelines for noise reduction measures on freight wagons', available at https://ec.europa.eu/competition/state_aid/cases1/202032/285944_2179737_56_2.pdf.

[239] See 'SA.55443: Aid for the implementation of projects to reduce noise emissions by freight wagons, available at https://ec.europa.eu/competition/state_aid/cases1/20202/282485_2122602_110_2.pdf.

[240] See 'SA.51229: Norma Retrofit: Measures to support the rail transport of goods in Italy, available at https://ec.europa.eu/competition/state_aid/cases/277288/277288_2050978_99_2.pdf.

[241] See 'SA:50165: Support for the promotion of energy efficiency in rail transport' https://ec.europa.eu/competition/state_aid/cases/272954/272954_2028683_135_2.pdf.

[242] Federal Railway Authority, Noise reduction on existing freight wagons. EBA - Noise reduction on existing freight wagons (bund.de) [German].

[243] See recitals 18-21, SA.57271 285944_2179737_56_2.pdf (europa.eu).

[244] See Rail noise protection: A brief chronicle of federal initiatives, BMDV - Rail noise protection: A brief chronicle of federal initiatives (bmvi.de) and noise protection in rail transport, 2021, available online at BMDV - Lärmschutz im Schienenverkehr (bmvi.de) [German].

[245] See Rail noise protection: A brief chronicle of federal initiatives, BMDV - Rail noise protection: A brief chronicle of federal initiatives (bmvi.de) and noise protection in rail transport, 2021, available online at BMDV - Lärmschutz im Schienenverkehr (bmvi.de) [German].

caused a drastic drop in rail freight traffic volumes, and the German authorities extended the period to accumulate mileage for the 2021 into the first 6 months of 2021 to ensure that freight wagon owners could claim a level of aid which represented their freight wagons normal yearly mileage.

The remaining three schemes allowed for aid to be submitted for both the retrofit and acquisition of rolling stock. The Austrian ERP Transport program (SA.33669) and Special Guidelines for the programme of aid for innovative combined transport (SA.41100 and SA.60132) which both include general provision of the procurement of railway carriages for intermodal transport. It was not possible to locate ex-post analysis on these schemes.

The Italian scheme interventions for the development of intermodal transport in the Friuli Venezia Giulia (FVG) region (SA.47779) provided a 2016-2021 extension to a 2010-2015 scheme to modernise both freight transport services and infrastructure. As part of the renewal the Italian authorities provided an analysis of the scheme between 2010-2015, they found that the scheme contributed to an annual increase of intermodal traffic of 11.9% in 2014, nearly double the rate of increase before the scheme started in 2009 (5.2%).

CONCLUSIONS:

Ten rolling stock State aid schemes (omitting interoperability schemes) were identified. Four of them had an ex-post analysis, 2 (2/4, 50%) of the schemes mostly achieved their objectives, one (1/4, 25%) had mixed results and one (1/4, 25%) was a failure.

3.6.2.2 Acquisition and retrofit of rolling stock in the rail industry (track access charges)

Given the significant costs related to the introduction of innovative and environmentally friendly technologies, some MS have introduced a reduction in TAC to incentivise the implementation of these technologies.

Sweden used to charge emissions from diesel-powered engines, but such surcharge has been phased out following the Commission Implementing Regulation 2015/909. Originally, TAC in Sweden were dependent on both the type of engine and of vehicle (locomotive or railcar), as well as the self-declared level of fuel consumption. For what concerns the type of engine, reduced TAC were envisaged for rolling stock using engines that met the EU emission standard of Stage IIIA or Stage IIIB.[246] Also Switzerland, Finland and the Czech Republic have applied in the past surcharges to diesel rolling stock, although in these cases the TAC were simply based on gross tonne-km;[247] in this way, heavier rolling stock was, *ceteris paribus*, charged more, as it consumes more fuel and, this, pollutes more.[248]

[246] Stage IIIA and Stage IIIB were introduced with the Directive 2004/26/EC. Stage IIIA covers engines from 19 to 560 kW, including constant speed engines, railcars, locomotives, and inland waterways vessels. Stage IIIB covers engines from 37 to 560kW, including railways and locomotives. According to power brackets (e.g., 130-560kW), different levels of maximum emissions of carbon monoxide, hydrocarbons, oxides of nitrogen, and particulates are identified.

[247] Gross tonne-km is a measure that considers both the weight of the freight and of the vehicle itself. Net tonne-km, on the contrary, does not take the weight of the vehicle into account.

[248] According to Zheng, Lin, Allwood and Dean (2021), for high-speed rolling stock, aircraft and automobiles, a 20% weight reduction could lead to about a 10%-16% increase in fuel efficiency. Long-distance passenger trains could save 4% energy consumption for every 10% weight reduction, and the energy savings could be 8% for subways and urban trains, according to the 2011 final report from the Institute for Energy and Environmental Research. In a less recent study by J. N. Cetinich (1975), fuel consumption is estimated to increase by 1 percent when a six-axle unit is used where a four-axle unit (with equivalent horsepower and other characteristics) would suffice, directly stemming from the fact that the former is approximately 50 percent heavier than the latter. Although the magnitude of these estimate might not be extremely reliable because the study dates back half century, during which innovations and new technologies have improved fuel consumption, the positive relationship between rolling stock weight and fuel consumption still holds.

Until 2020, in some countries,[249] a reduction of TAC was envisaged also to incentive the reduction of noise pollution caused by rail freight traffic, which is the second largest source of environmental noise in Europe after road transport, with 22 million people exposed to high levels of noise.[250] In these countries, RU were charged noise-differentiated TAC (NDTAC), which incentivised the use of low-noise brake systems; indeed, by making higher noise traffic more expensive, countries encouraged wagon owners to invest in low noise braking systems, thus reducing noise pollution. The NDTAC system is not applied anymore in Germany since 12 December 2020,[251] when the "German Railway Noise Mitigation Act" entered into force, prohibiting RU from operating noisy freight trains on the national network.[252] In Austria, Czech Republic, and Netherlands the NDTAC system has been in place until December 2021.[253]

In Italy, the IM has been allowed to include in the access charges a component that boosts the reduction of noise effects following the Decision 96/2015 of the Transport Regulator Authority. Nonetheless, NDTAC has not been introduced by the Italian IM so far.

CONCLUSIONS:

Some Member States have structured operating aid to incentivise beneficiaries to upgrade existing rolling stock through offering higher track access charge reductions for more environmentally friendly rolling stock or rolling stock with lower noise brake systems.

3.6.2.3 Acquisition and retrofit of rolling stock in the rail passenger industry (omitting interoperability schemes)

We identified two schemes which applied solely to the acquisition and retrofit of passenger rolling stock. Namely, the French 'Metro of the Future' scheme (SA.35092)[254] and the Hungarian MFB Public Transport Development and Financing Program (SA.35448)[255]. Neither of these schemes provided useful ex-post analysis.

CONCLUSIONS:

The Consortium identified two schemes which concerned acquisition and retrofit of rolling stock in the rail passenger industry and could not locate any relevant ex post analysis.

3.6.2.4 Acquisition and retrofit of vessels in the inland waterway industry

The remaining schemes concerned acquisition and retrofit of vessels in the inland waterway industry which did not also include provisions for the rail industry.[256] Four MS in our sample notified schemes which concerning solely the acquisition and retrofit of rolling stock in the inland waterway industry. Namely Czech Republic (SA.38003, and

[249] Austria, Czech Republic, Denmark, Germany, Switzerland, and the Netherlands, according to IRG-Rail (2020) "Review of charging practices for the minimum access package in Europe".
[250] European Environmental Agency (2020).
[251] DB Netz AG (2021).
[252] A freight train is considered "noisy" if at least one wagon in the train is equipped with cast-iron brakes. The Act also applies to passenger trains containing at least one noisy freight wagon.
[253] Commission Staff Working Document Evaluation of "Commission Implementing Regulation (EU) 2015/429 and the rules for noise differentiated track access charges" (2021).
[254] See SA.35092 – France 'Aid from the French Environment and Energy Management Agecny to Alstom and the Régie Autonome des Transports Parisiens for the "Metro of the Future" project. Available at https://ec.europa.eu/competition/state_aid/cases/249320/249320_1530275_143_2.pdf.
[255] See SA.35448, – Hungary – MFB Public Transport Development and Financing Program. Available at https://ec.europa.eu/competition/state_aid/cases/248358/248358_1437940_102_2.pdf.
[256] (note that if schemes included provisions for both inland waterways and railways, they were assessed in section 1.13.201).

SA.43080[257]), France (SA.35139, SA.48804, SA.57398[258]), Germany (SA.57137[259]) and Italy (SA.58817[260]). The total budget for these schemes over the period was at least 135.90 million, with 7.59 million in 2012 and 33.91 million in 2021.

One of the four schemes included useful evaluation. SA.38003 states that none of the projects under subsection 2 of the Czech scheme (projects to increase intermodality) requested an aid intensity below 49%, and that between 2008 and 2013 66% of projects were abandoned due to the inability of applicants to self-fund the remaining 51% of costs[261]. This threshold was increased to 85% in SA.43080[262].

CONCLUSIONS:

> The Consortium identified four schemes which concerned acquisition and retrofit of vessels in the inland waterway industry, one of which had ex-post analysis, which was mixed.

3.6.3 Aid for combining sustainable modes of transport road vehicles in intermodal transport

Combining electric vehicles with rail would result in an intermodal transport with very limited CO_2 emissions. According to the literature and reports on the use of sustainable modes in intermodal transport, there is no objection from transport companies or drivers to use more sustainable modes of transport vehicles for the road leg of intermodal services. In addition, the academic literature explains that the use of sustainable vehicles is compatible with pre- and post-haulage distances both in terms of feasibility and efficiency.

The main barrier to the implementation of battery electric or hybrid road vehicles in intermodal transport seems to be the initial investment cost, while catenary electric trucks require infrastructure development and hydrogen engines are energetically expensive. The survey replies confirm that aid to purchase a sustainable truck or aid to invest in terminals' charging infrastructure could be helpful. This suggests that specific aid for subsidising either charging infrastructure development or the purchase of more sustainable vehicles should encourage a modal shift from road-only to sustainable intermodal services. The scope of this shift would be highly dependent on electricity prices.

Additional information from the stakeholder survey can complement this Section. We have received six relevant replies[263] from five MR and one RU. They agree that specific aids to intermodal solutions where sustainable vehicles are used for the first and last mile services could increase the demand for rail freight transport and make it more convenient as compared to road-only transport. On the one hand, they all agreed or strongly agreed that aid to purchase a sustainable vehicle and aid to invest in charging infrastructures in terminals could be helpful. On the other hand, there is less consensus on aid to support energy costs or aid to use terminal services. In the normal circumstances of spring 2022, stakeholders noted that support to electricity costs was not

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[257] See SA.38003 'Prolongation of the scheme N 358/2007 – State aid scheme for operators for the modernisation of inland waterway freight transport vessels.' Available at https://ec.europa.eu/competition/state_aid/cases/251186/251186_1535777_128_2.pdf and SA.43080 State aid scheme for modernisation of inland waterway freight transport. Available at https://ec.europa.eu/competition/state_aid/cases/260429/260429_1837217_158_2.pdf.

[258] See SA.35139, https://ec.europa.eu/competition/elojade/isef/case_details.cfm?proc_code=3_SA_35139 SA.48804, https://ec.europa.eu/competition/state_aid/cases/270577/270577_2007190_113_2.pdf and SA. 57398 https://ec.europa.eu/competition/state_aid/cases1/202032/286154_2178572_74_2.pdf [French].

[259] SA.57137, German Aid scheme for modernisation of inland waterway fleet, see https://ec.europa.eu/competition/state_aid/cases1/202131/293082_2304677_116_2.pdf.

[260] SA.58817, State aid to support freight transport by inland waterways in Italy, see https://ec.europa.eu/competition/state_aid/cases1/202144/SA_58817_B0FF097C-0000-C96D-BCBA-34B4F8441773_104_1.pdf.

[261] See recital 36, SA.38003 'Prolongation of the scheme N 358/2007 – State aid scheme for operators for the modernisation of inland waterway freight transport vessels.' Available at https://ec.europa.eu/competition/state_aid/cases/251186/251186_1535777_128_2.pdf

[262] Note that this scheme was accessed under the EEAG guidelines not the railway guidelines.

[263] From Austria, Czech Republic, France, Germany, Lithuania and Poland.

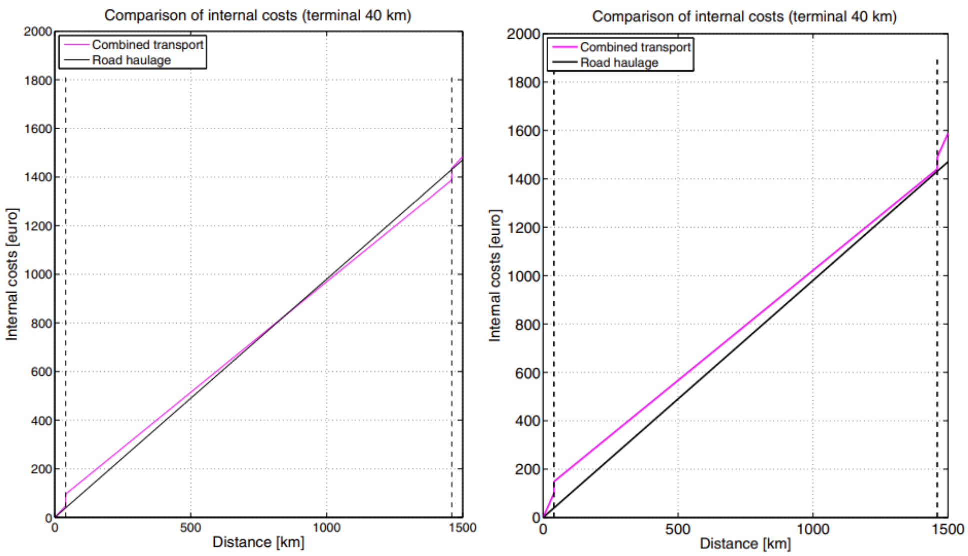
needed in Austria, not much needed in France and strongly needed in Poland. This assessment is likely to change during the energy crisis when energy prices rise significantly.

Basma et al. (2021) evaluate the Total Cost[264] of Ownership (TCO) of diesel and battery electric long-haul trucks in Europe.[265] Battery electric trucks are already at TCO parity with diesel trucks in Germany, France, and the Netherlands thanks to currently adopted national policies such as purchase premiums and exemptions of road tolls for electric vehicles. Moreover, in their cost model the truck net cost (without national intervention) represents between 45-55% of the TCO of electric trucks, while it represents between 20-25% of the TCO of diesel trucks. Without state support, battery electric trucks' TCOs are also 15-25% higher, and it is almost exclusively due to truck net costs. This shows that the initial investment cost is a key matter. They also find that differences in electricity and diesel prices have a strong impact on the competitiveness between both truck types. In particular, low diesel prices delay the year that electric trucks reach TCO parity with diesel trucks. In terms of policy recommendations, the paper concludes that purchase incentives are a short-term powerful policy tool to help close the TCO gap. Support for charging infrastructure is not significant to reduce battery electric trucks TCO in comparison with diesel trucks because of the low share of infrastructure charges in the total electricity prices.

Another recent study by Carboni and Dalla Chiara (2018) shows that transport companies are increasingly using electric vehicles for low classes of weight (5–7.5 tons), and of hybrid and natural gas engines for higher weights. According to this article, the hybrid or electric alternatives are usually compatible with the distances covered during pre- and post-haulage, considering the location of charging stations in the terminals. The main positive effects of using electric or hybrid lorries are reflected in the lower costs for energy consumption.

Using a simulation method, the paper considers a medium pre-and post-haulage of 40km and a total leg (road+rail) of up to 1,500 km and compares costs for road-only and intermodal transport with both electric (left) and conventional trucks (right).[266] Figure 18 presents the cost comparison.

Figure 18: Comparison of costs for road



Source: Carboni and Dalla Chiara (2018).

[264] Including the vehicle purchase cost, taxes, energy costs, road tolls, maintenance costs, charging station infrastructure costs.
[265] France, Germany, Italy, The Netherlands, Poland, Spain and the UK.
[266] Note that the model does not consider the initial investment cost of purchasing a truck.

With electric trucks, combined intermodal transport becomes less costly compared to road-only at around 700 km. In comparison, internal costs of combined intermodal transport with conventional trucks are systematically higher than road-only transport. Indeed, authors compare road-only to combined intermodal transport with and without electric trucks for the road leg of the combined intermodal transport. Their conclusion is that the use of electric trucks could make combined intermodal transport systematically more convenient as compared to road-only. However, we must keep in mind that they do not consider initial investment cost of electric trucks. Thus, it shows that the use of electric trucks could be operationally efficient.

Moultak et al. (2017) compare three technologies for zero-emission heavy-duty freight vehicles: electric plug-in, electric catenary or in-road charging and hydrogen fuel cell. Compared with diesel vehicles in 2030, electric catenary technology results in 25%–30% lower costs, in-road induction in 15%–25% lower costs, and hydrogen fuel cells in 5%–30% lower costs. Another outcome of this paper is that the hydrogen fuel trucks might be a solution for long distances, while electric vehicles may be useful, in economic and environmental terms, to cover shorter distances (range of approx. 100–200 km). However, the key barriers for battery electric vehicles include initial vehicle cost, charging time, and maintaining vehicle cargo weight and volume capacity. For electric in-road charging vehicles, the main drawbacks are the costs and the implementation of the infrastructure needed for such trucks. Hydrogen fuel cell vehicles also require a high initial investment and the renewable hydrogen is also relatively costly.

MacHarris et al. (2007) examines the potential use of electric or hybrid trucks for the pre- and post-haulage operations. There are no objections from company managers and drivers to use hybrid and electric vehicles for urban deliveries, but the authors conclude that the main obstacle will be the vehicle investment costs. The paper also estimates annual costs of different types of vehicles and concludes that combining sustainable heavy-duty vehicles with rail, inland waterway or short sea services could result in an attractive sustainable transport system. The calculations show that the system is also organisationally and financially feasible without any subsidies, but their estimations must be taken with caution because they are based on 2007 data.

CONCLUSIONS:

Sustainable vehicles such as battery or hybrids vehicles could be used for pre- and post-haulage in combined transport and could operate efficiently. The main obstacle to the implementation of such trucks is the initial cost of investment, especially for battery electric trucks.

3.7 Conclusions

The qualitative and quantitative evidence collected by the Consortium suggests that public financing might be needed to encourage the replacement or modernisation of the rolling stock fleet. The rolling stock fleet is quite old and the rate of introduction of innovative and clean technologies is unsatisfactory.

A significant portion of the fleet is close or already beyond its expected useful life, particularly as regards passenger trains. Locomotives represent a partial exception to this picture and are relatively younger. Multiple sources of evidence confirm that passenger rolling stock is generally perceived in worse conditions than freight rolling stock, though with relevant differences across MS. Several sources of evidence also suggest that the current rate of renewal may be suboptimal. Keeping constant the rate of renewal observed in the past 10 years, the size of the rolling stock fleet will decrease over the next 10 years.

The Consortium investigated the causes of this situation. First, the observed low rate of renewal may reflect the fact that the costs associated to access to rolling stock are significant, and such that access to rolling stock represents a significant barrier to entry and/or expansion for existing or potential RU. This is especially the case in the passenger segment.

Among other things, several stakeholders consulted by the Consortium revealed that differences in the rail infrastructure across MS, which imply that passenger trains and locomotives are tailor-made for each infrastructure, contribute to increasing the costs related to access to these categories of rolling stock since markets where rolling stock is exchanged are smaller, and mainly national in scope. hence less attractive for leasing companies. Leasing companies play an important role in making access to rolling stock easier. Freight RU seem to increasingly lease their rolling stock fleet, rather than owning and maintaining it, especially as regards freight wagons. The role of leasing companies is also growing for locomotives, since, given the international dimension of the business, the demand for multi-system locomotives is increasing: multi-system locomotives which can travel on multiple electrification systems are, however, costlier. On the other hand, the role of leasing companies is negligible for the provision of passenger rolling stock.

The differences in the rail infrastructure across MS may contribute to making access to rolling stock costlier and more complex also because they may provide rail incumbents with market power in the provision of used rolling stock in their country, virtually making them the only suppliers. Incumbents have limited incentive to sell it or lease it to existing or potential competitors, and may prefer to scrap it or keep it unused (especially if storage costs are low) even if it could still be used. The overall qualitative and quantitative assessment carried out by the Consortium seems to confirm that incumbents may indeed engage in such behaviour, especially for what concerns passenger and tractive rolling stock. Whether this may substantially distort competition is unclear, and will depend on the extent to which market entrants can successfully substitute access to second-hand rolling stock with other sources of rolling stock, and in particular with the lease or purchase of new rolling stock. One stakeholder consulted by the Consortium suggested that one factor that may make the investment needed to purchase new rolling stock particularly high, and possibly unsustainable for certain small operators, is the fact that manufacturers of passenger rolling stock may prioritize large orders.

Based on the overall evidence, it can be concluded that encouraging technical standardisation, thus interoperability of rolling stock across the EU seems a very important step to facilitate access to rolling stock, and ultimately reduce its costs. This seems to be in the Commission's agenda already: the ERTMS entails standards for management and interoperation of signalling for railways by the European Union. However, the targets that the Commission set in terms of km of tracks equipped with the ERTMS have not been met and deadlines have been postponed. This might be an indication that public financing, possibly directed to IM, is needed to foster the introduction of the ERTMS, and the interoperability of rolling stock that would result. The incentives of the rolling stock owners in relation to the introduction of the on-board signalling systems must also be considered. It seems that only three MS have issued State aid measures to support the introduction of on-board ERTMS. These schemes have been largely unsuccessful because potential beneficiaries considered the funding cap insufficient to implement to install the necessary equipment; this highlights that to foster the switch to the EU-wide standards envisaged by the ERTMS, vehicle owners may need to be subsidised in addition to IM, and to a greater extent to what has been done until now.

We understand that for what concerns the electrification system, harmonising the various infrastructure may not be feasible. This implies that multi-system locomotives are needed: from the evidence available, it does not seem that this factor represents a significant barrier to entry and/or expansion.

The Consortium investigated further drivers of the sub-optimal condition of the rolling stock fleet, and in particular the existence and nature of factors constraining RU's ability to invest in the retrofitting or replacement of rolling stock, and found out through stakeholder consultation that constraints are mainly of financial nature. Small operators may in particular not have access to credit at competitive conditions. This factor may contribute to the observed low renewal rate of rolling stock, which may represent an obstacle to the meeting of the objectives of the modal shift to rail.

Not only the rate at which rolling stock is replaced seems sub-optimal, also the rate at which it is retrofitted to introduce innovative and clean technologies appears too slow.

This is because market forces alone will not lead to the introduction of these technologies, and an impasse may instead result. One of the reasons is that being equipped with these technologies will bring benefits only to the extent that they are introduced at a certain scale. From the existing literature and stakeholder consultation, it can be concluded that to encourage the introduction of these technologies, EU-wide coordination might be needed, for instance through an update of the relevant TSIs that makes the introduction of these technologies mandatory after an appropriate transition period. Economic analysis mainly based on findings from the literature suggest that subsidies to first-movers could also help fostering the adoption of these technologies, although their intensity would likely need to be high enough to cover the whole transition period, until the first-movers can reap the benefits of their investments. Another route to encourage the introduction of innovative and clean technologies is that of reducing TAC paid by RU to IM when the rolling stock is equipped with these technologies.

More broadly, the above suggests that policies aimed at encouraging the renewal of rolling stock might be warranted. The majority of investments in rolling stock in the recent past were backed by public financing; the extent to which state support measures contributed to these investments is, however, unclear. Moreover, the available evidence also shows that the contribution of private financing to the renewal of rolling stock has been steadily increasing since 2011, and is expected to further increase in the future. It is therefore unclear whether more or less state support measures will be needed for the purpose of the renewal of rolling stock.

State support aimed at encouraging the renewal of rolling stock does not necessarily have to take the form of aid directly granted for the purchase of new rolling stock. Introducing policies aimed at lowering the interest rates that small operators have to pay to receive a loan from credit institutions for the purpose of purchasing rolling stock might be an alternative route.

Encouraging the renewal of rolling stock may also help overcome the impasse in relation to the introduction of innovative technologies, as there is evidence that RU tend to wait for the replacement time to introduce them.

It should be noted, however, that the productive capacity is also limited, as noted by stakeholders consulted by the Consortium. Therefore, measures aimed at incentivising investments in the renewal of rolling stock alone may be ineffective. Analysing in more depth the upstream market for the manufacturing of rolling stock may prove useful to understand whether, for the rail sector to meet the objectives of the modal shift, investments to expand the productive capacity of rolling stock may be needed.

4. Costs, revenues and profitability of rail freight transport

4.1 Introduction and problem definition

The modal share of rail freight transport has been well below the political targets for years. A renewed effort to boost rail transport requires a solid understanding of the costs, revenues and thus profitability of rail freight transport in Europe. Such data is required to design appropriate policies and State support measures that can effectively result in an increase of the rail modal share. Generally, the preferred measure for cost, revenues and profitability is Eurocent per net tonne-kilometres (tkm). The tkm measure tracks the actual transport performance (freight weight and distance) well and is readily available from official statistics.[267] While tkm is the best metric to get an overview of the entire market, it does not necessarily reflect the unit which is subject to price negotiations between RU and their customers. End-customers may sometimes purchase intermodal transport services per unit (often a "truckload", formally TEU, Twenty-foot

[267] Eurostat notes that tkm is less likely to be biased than other measures, see section 3.4 in: https://ec.europa.eu/eurostat/cache/metadata/en/rail_pa_esms.htm.

equivalent unit). Block trains are usually put out for tender, so the unit is effectively one full train.

As regards the estimation of costs and revenues per tkm, we consider two approaches: top-down and bottom-up (also known as activity-based) approach. A top-down approach makes use of aggregate data, e.g. costs or revenues for all rail freight services of a railway undertaking on an annual level, and derives a measure by simple division of total costs or revenues by transport volume.[268] This type of aggregated information is often found in the annual reports of railway undertakings, market reports by regulators, or statistical offices. The derived total cost and revenue figures are a good depiction of the general market situation, but a breakdown of these figures into its components or for different market segments requires additional data. Moreover, this approach requires assumptions to simulate hypothetical market situations which are not covered by the available data. Lastly, inconsistencies may arise, because different data sources may allocate shared costs (i.e. costs that are relevant for rail freight services in different market segments at the same time) in different ways.[269]

Conversely, activity-based modelling identifies the relevant cost items from a technical production perspective, e.g. modelling a specific train route and categorising all costs that are incurred in this context. These individual cost items are summed up to derive total costs. For instance, Lupi et al. (2019) identify and quantify cost items that (i) vary with distance (e.g. track access charges and traction costs), (ii) vary with time (e.g. labour costs) and (iii) are fixed at the rail service level (e.g. transshipment costs).[270] This approach is flexible as it allows the user to vary the considered rail freight service, even including hypothetical routes, and a split of total costs into cost items is inherently easy. Furthermore, the approach accurately captures marginal cost items as long as the underlying micro-level assumptions are reasonable, e.g. specific wages per hour and costs for electricity. However, challenges arise in converting all cost categories into a unified measure and the method is potentially imprecise for cost items that are largely fixed or shared between different rail freight services.[271] Also, it is unlikely that the results of such a micro-based approach actually match aggregate country-wide or company-wide figures.

Irrespective of the selected approach, the costs and revenues associated with rail freight transport depend on a number of factors ("dimensions"). For the purposes of our analysis and to address the study questions 1-5 (see Annex 3 for the full list of study questions), we focus on five main dimensions: (i) country, (ii) train types, (iii) market participants (iv) freight categories and (v) border-crossing. In addition, we consider the impact of changes in (vi) travel distance and (vii) train length on costs and revenues. These dimensions are explained in more detail below.

Country: Costs, revenues and thus profitability of rail freight services may differ between geographical areas. We consider various reasons for differences between countries: differences in geography, available infrastructure, network density, varying labour costs and energy costs, taxation and regulation, and country-specific product mix effects, e.g. when a particular market segment is more common in one country than in another.

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[268] For instance, the 2020 annual report of the Lithuanian incumbent LTG Cargo indicates revenues of 396m EUR and a transport volume of 15.9b tkm. Simple division yields revenues of 2.49 Eurocent per tkm, see https://www.litrail.lt/documents/10279/0/AB+LTG+Cargo+annual+report+2020/dc0e8a86-8454-46ff-91ff-29e1adc5f44a.
[269] For example, if a locomotive is used for block trains and single-wagon transport in the same year, the costs for this locomotive need to be allocated to these types of services by a certain rule.
[270] See also Gattuso and Cassone (2020) for a similar methodology.
[271] For instance, maintenance and amortisation cost of rolling stock increase with distance, but also over time. Similarly, overhead costs like IT and administration are difficult to incorporate without arbitrariness. This may be particularly severe with single-wagon transport which is characterised by substantial system costs. IMC Worldwide (2017) does build a partially activity-based model and derives cost that do not vary much between train types.

Train types: One of the most obvious drivers of cost variation is the so called "production system". For the purpose of this study, we will consider block trains, single-wagon operations and intermodal transport. We will refer to the 3 variations as *train types*. See section 1 for a brief introduction of the different train types. [272]

Block trains refer to trains that shuttle between two sidings and typically transport a large number of wagons with a single commodity, most commonly bulk goods. Due to economies of scales, the cost per tkm is fairly low and block trains often outcompete road transport. Thus, they tend to be profitable. Block train services usually do not involve highly complex logistics. They are mostly simple point-to-point connections. This makes this type of rail freight service attractive for small RU and new entrants. Therefore, block train services in many regions are put out for tender in a competitive market, so that RU tend to realise only small, but still positive margins.

Single-wagon transport entails a main leg with a multitude of wagons, but also local feeder and distribution legs to or from start, end and intermediate locations along the main leg. This train type can deliver goods *door-to-door* without changing mode if both origin and destination are connected to the railway network. In contrast to block trains, single-wagon provides a *multi-client* service, because the mainline locomotive transports wagons of different clients. Nevertheless, freight categories transported with single-wagon resemble those of block trains: commonly they are heavy goods of low value, the transport of which is not time-critical (XRail interview). We assess that single-wagon transport is generally unprofitable, *inter alia* due to low volume effects of feeder traffic, high costs for additional marshalling requirements and low utilisation (Woodburn 2017, p.6). A specific problem for single-wagon transport is the requirement for additional dedicated infrastructure, whose investment costs are challenging to recuperate (see section 2.5).[273]

For the purpose of this study, we define *intermodal transport* as rail freight transport using an intermodal loading unit such as containers or semi-trailers. In this case, the rail freight service is one leg in an intermodal transport chain, which involves additional modes of transport, such as road or inland waterway. Like single-wagon, the entire intermodal transport chain is a *multi-client*, door-to-door service. In this Section specifically, we will only consider the rail leg of the intermodal transport chain. The market for intermodal transport keeps growing and remains profitable, despite strong competition within the segment and externally from road (see e.g. UIC 2020b) putting pressure on prices.

However, innovative solutions have driven down operational expenditures. ECM Ventures (2022, p.40) argues that new entrants in particular realised cost reductions through lean and agile organisation structures and by focusing on high demand segments and corridors. As in the case of block trains, intermodal transport is usually conducted as a shuttle service between two intermodal terminals.[274] For instance, results from the stakeholder consultation indicate that more than 85% of intermodal transport volume is conducted by block trains.[275] Consequently, the costs of both train types are fairly similar.[276]

Freight categories: Freight categories refer to the types of commodities transported. For the purpose of our analysis, we make use of the *Standard goods classification for*

[272] Some empirical examples from ongoing/recent State aid cases suggest that most railway undertakings (both incumbents and new-entrants) tend to assemble trains by combining all three types of wagons. We therefore consider a simplified classification of the different train types for the purposes of the profitability analysis.

[273] See also the box on single-wagon transport in Section 4.2.3 that discusses the history, specific issues and prospects of single-wagon transport in more detail.

[274] Stakeholder consultation (interviews and survey results).

[275] Three out of five RU who provided input through stakeholder consultation provided a range of 96% - 100% that constitutes the share of intermodal transport volume conducted by block trains, with one RU suggesting a range of 86%-100% for block trains and 11%-15% for single-wagon operations.

[276] Regarding the rail leg, there are two opposing considerations. First, intermodal rolling stock is usually cheaper than specialised wagons for bulk goods (Roland Berger 2021, p.49). On the other hand, block trains transport higher volumes which boosts economies of scale in terms of tkm.

transport statistics abbreviated as NST (2007).[277] There is little public information on costs and revenues for particular types of cargo. To the extent there are differences in costs, these are to some degree attributed to the train type with which the respective goods are transported. For instance, a typical coal transport may go directly from a coal mine to a coal-fired power plant and benefit from the low costs of heavy block-train transport. Table 2 in Section 1 shows that the freight categories most commonly transported by rail are bulk goods, indicating that rail transport is competitive and profitable for these types of freight. As regards intermodal transport, the costs and revenues of containerised transport are mostly independent of the type of cargo. In fact, even the railway undertakings conducting the service might be unaware of the content of the transported containers.

Some freight categories require specific rolling stock, which drives costs per tkm to some degree. For instance, automobiles are transported in specialised wagons that systematically differ from typical rolling stock, refrigerated vans are used to cool the freight, tank wagons to safely transport hazardous liquids or "Presflo" to transport cement and other powdered goods. The rolling stock moving containers is standardised and typically less costly than wagons for block trains and single-wagon transport.[278] Heavy cargo increases traction costs, and in some cases track access charges.

Market participants can be grouped into incumbents and non-incumbents. On the supply side, there are indications that the cost and revenue structure of national rail incumbents differs from that of new entrants.[279] Two opposing effects stand out: operational efficiency and economies of scale and scope. Regarding efficiency, incumbents faced less cost pressure prior to market liberalisation and some of their historic inefficiencies might carry over to the present and future. For instance, incumbents typically have higher labour and overhead costs. On the other hand, they have competitive advantages due to their size. This materialises in economies of scale (e.g. lower purchase prices when procuring large volumes of rolling stock) and scope (e.g. a large network for single-wagon services).[280]

Transport distance & train length/load factor: As indicated before, rail freight transport may benefit from economies of scale due to low variable costs and high fixed costs. Indeed, rail transport has a lower share of variable costs compared to road.[281]

Rail freight transport is characterised by many cost items that are fixed at the train service level, i.e. are incurred only once per turn, or even at a higher level. Therefore, increasing the transport distance reduces the costs per tkm.[282] The literature is divided over the minimal distance from which rail starts exerting competitive pressure on road. We scrutinise the issue of minimum competitive distances in Section 4.4.

As regards train length, economies of scale arise when multiple wagons are combined with a single locomotive to form a long train. The marginal costs of adding a wagon to a train are small compared to those of operating a second truck (Woodburn 2017, Transport and ICT 2017, see also the empirical analysis in section 4.3). The common

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277 See Section 1.

278 Roland Berger (2021, p.49) assesses that rolling stock costs in combined transport are lower than for block train and single-wagon. For a selection of rolling stock for different purposes, see e.g. Transport and ICT (2017, p.27ff). On the demand side, dangerous goods like nuclear waste entail higher revenues due to less elastic demand, see also Section 4.7.

279 For the purpose of this study we will define only the historic national rail operator as incumbent. For instance, the French incumbent SNCF is considered an entrant in Italy and Germany.

280 ECM Ventures (2022, p.40). See also https://ec.europa.eu/commission/presscorner/detail/en/ip_22_681 (accessed on 14 June 2022).

281 Izaldi et al. (2020, p. 16) illustrate the fixed and variable cost items of railway transport.

282 See Sternad (2019) for an estimation of the relation of costs and distance in Slovenia. Our preliminary assessment indicates that these cost benefits are partially passed on to customers, see e.g. the price list of the German incumbent: https://www.dbcargo.com/resource/blob/5767020/55b2dc9c02e38888c407cb9cce3363b0/DB_Cargo_Standard-Rates_Provisions2021_ENG-data.pdf.

maximum length of trains in Europe is 750m.[283] The Baltic states are a notable exception as their infrastructure allows for heavier and longer trains.[284] Outside of Europe, trains can be much heavier and longer. While in Europe the maximum length of a train is always under 1,000 meters, the maximum length of trains in countries like US and Canada span between a minimum of 2,000 meters to a maximum of 5,600 meters between the two countries. Moreover, we find similar trends in Australia, China and South Africa.[285]

The change in revenues per tkm with increasing transport distances and longer trains generally depends on competition within the rail sector and between rail and other modes of transport. Consequently, it cannot be assumed that revenues change proportionally with longer distances and the number of wagons per train. Still, longer transport distances and higher transport volumes lead to lower costs per tkm for rail freight transport, making rail transport more competitive when compared to road transport. Therefore, longer distances and higher transport volumes increase the probability that rail freight operations are profitable.

Cross-border transport: The literature mentions inefficiencies when crossing national borders. Cross-border traffic is characterised by problems with respect to technical interoperability and an unharmonised set of regulations and standards. These issues often manifest in waiting times at the border and higher costs for rolling stock and labour.[286] The magnitude of the delay varies with the specific border.[287] Although this is a time delay, border-crossings are usually modelled as a monetary one-time penalty on costs (see e.g. Troche 2019, p.180). Furthermore, non-electrified border-crossings can impede operational efficiency.[288] Also, local train staff or staff with foreign language skills are required (Roland Berger 2021, p. 102). Conversely, road transport does not suffer much from obstacles related to the crossing of intra-European borders.

Other factors: Another cost differentiator is the traction type. Generally, the operational costs of electric locomotives are lower than diesel haulage.[289] However, the option to realise these benefits is linked to the electrification of the rail network, especially its main corridors. Another cost factor is the degree of rolling stock modernisation. Outdated locomotives and wagons incur higher operating and maintenance costs. Investments into modernising the rolling stock fleet reduce operational expenses, but increase the need for capital expenditure.

In the two subsequent Sections, we provide a cost and revenue estimates for rail freight in Europe that is structured along the dimensions discussed above. The estimates come from a database built on publicly available data sources and data received through stakeholder consultation covering the following thirteen European countries: Austria, Czech Republic, France, Germany, Italy, Lithuania, Netherlands, Poland, Romania, Slovakia, Spain, Sweden and Switzerland (henceforth, "the database").[290] Publicly available sources comprise of company annual reports, market regulator reports, statistical offices (for example, Eurostat, independent regulators' group (IRG) and UIC) and stand-alone rail freight-economics focused reports (for example by IRG, UIC or national transport

[283] On most major lanes, a minimum siding length of 750m is contractually agreed upon, see Economic Commission for Europe Inland Transport Committee (1985). In other parts of the world, e.g. the United States, train lengths can be much higher exploiting economies of scale even further.

[284] See e.g. IRG-rail (2021, p.23), https://railway-news.com/1000m-freight-train-from-china-en-route-to-kaliningrad/ and https://www.cer.be/sites/default/files/publication/160525_Longer%20Trains_Facts%20and%20Experiences%20in%20Europe_final_0.pdf.

[285] See "Longer trains Facts & Experiences in Europe": https://cer.be/sites/default/files/publication/160525_Longer%20Trains_Facts%20and%20Experiences%20in%20Europe_final_0.pdf.

[286] Often locomotives have to be changed. Multi-system locomotives are a costlier alternative to their single-system counterparts. Pucher and Schausberger (2016) illustrate these issues for the Austrian-Slovenian border crossing points.

[287] de Jong et al. (2016, p. 85) assumes waiting times of up to one hour for common borders. Gauge changes require an additional two hours.

[288] see e.g. https://www.railjournal.com/freight/germanys-unelectrified-border-crossings-holding-back-rail-freight-says-aps/.

[289] Panteia (2020) assesses that total costs with diesel are about 6-36% higher than with electric traction.

[290] Data collected by the Consortium based on public sources and stakeholder consultation.

authorities). The stakeholder consultation considers inputs from railway undertakings, infrastructure managers, intermodal operators and market regulators.[291]

The database is comprised of costs (partially broken down by different cost items), revenues, volumes, train length and travel distance for the year 2019 (the last full year before the COVID-19 pandemic), complemented where possible with 2018 and 2020 from the sources mentioned above. We refer to these values as "estimates" since there is usually no full transparency and consistency in the methodology underlying the calculation of costs and revenues across the different sources. For example, some sources treat subsidies differently than others and there is no general rule or definition regarding how to delineate costs and revenues for specific rail freight segments (for example, different sources may define costs that are attributable to single-wagon transport differently).

In the following Sections, we present the costs and revenues for rail freight services in Europe. First, we present in Section 4.2 ranges of costs, revenues and profits per tkm for the various market segments, addressing study question 1 and the second part of study question 7.[292] Subsequently, we simulate the effects of increasing the average train length and the average travel distance on costs and revenues in Section 4.3, thereby answering study question 5.[293] Section 4.4 presents available estimates of minimum profitable distance for rail, answering study question 11.[294] In particular, we discuss the market structure of short-distance freight operators in Section 4.4.3, with an aim to answer study question 6.[295] In Section 4.5 we analyse the effects of crossing borders on costs incurred by RU, addressing study question 4.[296] Price demand elasticities for different market segments are presented in Section 4.7, along with a discussion of the results to answer study questions 2 and 3.[297] Section 4.8 discusses several aspects of operating State aid measures, including an assessment of incentives for "start-up aid" in intermodal transport services, aid proportionality thresholds, and measures targeting track access charges, while answering study questions 8, 12, 15 and 22 respectively.[298] Finally, Section 4.9 concludes.

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[291] Please see Annex 21 for a detailed list of sources from which the key variables (costs, revenues and profits) are computed.

[292] "What is the cost-revenue structure of rail freight transport in terms of unit transport costs, (i) overall, (ii) for the main freight categories and main market segments, and (iii) as compared to road-only transport?"; "Are there examples of structurally loss-making (i) short-distance and (ii) long-distance rail freight services? For which market segments and geographical coverage? What type of financial incentives would render those services economically viable?"; see Annex 3.

[293] "The longer the rail journey and the train, the more competitive freight transport by rail becomes. a) What is the critical distance for rail freight transport services to be cost-covering in the three main market segments of rail freight transport, i.e. single wagonload, block trains, combined transport trains? b) What is the estimated train length, in relation to its composition (number and type of wagons) that ensures the financial break-even?"; see Annex 3.

[294] "What is the lowest, highest and average value of the minimum length of the rail leg, which makes the total cost of door-to-door intermodal transport operations cost covering or equal to road-only transport on same distances? If the situation is very diverse in Member States, please refer to qualitative homogeneous groups of Member States." see Annex 3.

[295] "What is the market structure of (i) short-distance and (ii) long-distance rail freight services?", see Annex 3.

[296] "How does the cross-border dimension of services affect the cost and revenue structure of rail freight transport?", see Annex 3.

[297] "To what extent is each of the main markets segments a price taker or a price setter and how does this affect their profitability?"; "What is the price-elasticity of the demand in the different main freight categories as well as in the different main market segments? To what extent are lower prices possible and sustainable?", see Annex 3.

[298] "Some Member States set up incentive schemes in the form of 3-year "start-up" aid to new freight combined transport services. Did the 3-year duration and the structure of those incentives prove appropriate to reach the viability of the subsidised services? If not, what would have been the economically appropriate duration and structure of the incentives in relation to the characteristic of the underlying services?"; "According to current rules, the aid amount that can be granted for rail infrastructure use and for reducing external costs without requiring Member States to demonstrate the need and proportionality of the aid is 30% of the total cost of rail transport. Is such a threshold still economically relevant?"; According to current rules, the aid to freight transport services is presumed to be proportionate if it does not exceed 50% of the eligible costs, and the eligible costs are the part of the external costs which rail transport makes it possible to avoid compared with competing transport modes. Based on the cost-revenue structure of the main freight

4.2 Presentation of costs, revenues and profitability per tonne-kilometre

4.2.1 Methodology, data and limitations

In this Section, we present costs per tkm, revenues per tkm and profitability for rail freight services disaggregated separately by country, market participant type (incumbents v. non-incumbents), freight category (as per the NST 2007 classification of goods for transport), and train type (single-wagons (SW), block trains (BT), and intermodal transport (IM)). Note that we present profits realised by railway undertakings with respect to all the dimensions. In particular, for intermodal transport, this relates to profits realised by RU for the rail leg only.

We present all reported cost, revenue and profitability estimates within each dimension, complemented with their average estimates.[299] In case of profitability, for which revenue and cost estimates need to be matched, we use two methods: (i) profitability based on reported cost and revenue estimates from the same source and (ii) profitability based on average cost and revenue estimates across all data sources.[300]

For the cost, revenue and profitability ranges per dimension, estimates in the database are pertinent to the time frame 2018 – 2020, of which approximately 49% of the data pertains to 2019, 22% of the data pertains to 2018 and roughly 27% to 2020.[301] Moreover, around 40% of data is from publicly available sources and around 60% of data is provided by the stakeholder consultation. Note that while a data request was sent to thirteen countries in total: Austria, Czech Republic, France, Germany, Italy, Lithuania, Netherlands, Poland, Romania, Slovakia, Spain, Sweden and Switzerland, we received some input from all the recipient countries except Romania. Further, only 4 out of the 12 respondents provided overall cost information which was nonetheless limited. We also found MR and RU to be relatively more responsive, compared to the other stakeholders. See Annex 5.

We exclude cost and revenue estimates higher than 30 cent/tkm to avoid skewing the results of the presentation. The differences in these estimates are mainly driven by different reporting methodologies, suspected data inconsistencies and unrepresentative business models.[302]

Given the limited data availability, the overarching limitation of the database is that it does not provide granular data broken down by several dimensions at the same time, e.g. costs per tkm broken down by country, train type and market participant type at the same time. This means that the database does not allow to analyse composition effects in costs and revenues and thus we cannot consider the correlation across different dimensions. For instance, while considering costs incurred by different market participants, although we see a clear difference in costs between incumbents and entrants, however, the underlying drivers of these differences remain unclear. This is because we

transport services referred in the questions above, are there cases where such aid would differ from the actual cost of the subsidised service?"; "Has any Member State put in place any measure for the reduction of track access charges linked to the innovative nature and/or environmentally friendly nature of the rolling stock used?", see Annex 3.

[299] Note that unless cost and revenue estimates per tkm are available, we divide aggregated costs and revenues over the respective volumes to derive the respective values per tkm. Further, the averages are computed as simple averages. We consider simple averages rather than weighted averages to ensure we do not overweigh those countries with large volumes, for example, Germany. Moreover, weighted averages could also result in double-counting volumes. For instance, there could be two sources providing volumes pertaining to the same dimension and upon aggregation, the resulting average may have a bias.

[300] Note that we use different sources under (i) for some exceptional cases where, for example, we derive the "overall" sector cost/revenue per tkm using data broken down by different dimensions and combining other sources. However, in most cases we already have more reliable data for the overall market sector dimensions.

[301] Note that just around 2% is pertinent to the 2015, and pertinent to Austria alone (Herry Study, 2020).

[302] Estimates from Germany, Spain, Switzerland and France with the following respective sources: UIC DB AG, UIC FGC (2019, 2020); stakeholder consultation; and non-incumbent Rhätische Bahn annual report (2019).

have too few cost/revenue figures that represent a combination of dimensions, i.e., for instance *market participant and train type.* Therefore, we cannot disentangle whether incumbents operate less efficiently or face higher costs because they operate costlier train types (e.g. single-wagon).

Generally, there is also a lack of transparency on how much State aid is included in the cost and revenue estimates since it is difficult to identify how such aid or subsidies are accounted for, i.e., whether in the form of increased revenues, dedicated extraordinary revenues or decreased costs. The information provided across the different sources is quite ambiguous.[303] Nevertheless, we provide a brief overview of the subsidies across different MS (see Section 4.8.1).

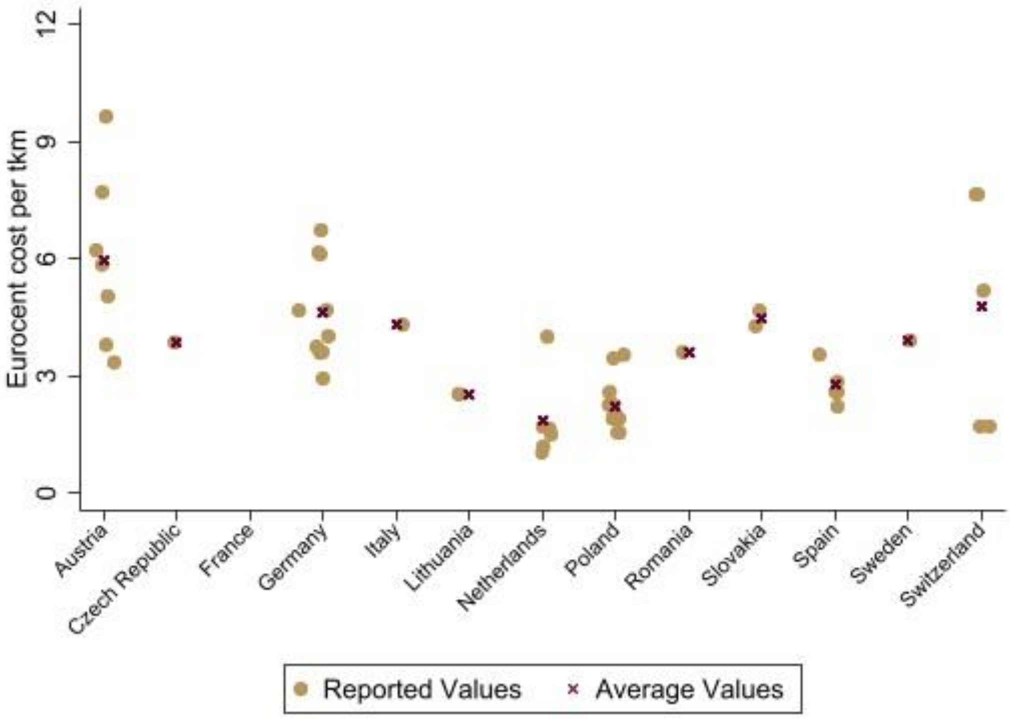
In Sections 4.2.2, 4.2.3, 4.2.4, 4.2.5 and 4.2.6, we present ranges of the reported and average costs revenues and profitability by individual dimensions (country, train type, market participant, freight categories and national/international scope).

4.2.2 Countries

Figure 19 provides the reported costs as well as average costs (represented by red crosses) of the rail freight sector for each *country* across all other dimensions, i.e. *train type*, *market participants*, *freight categories* and *national or international scope*, and *all sources* for 2019. Note that if we do not have data for 2019, we consider the year closest to 2019, i.e., 2018 or 2020.[304]

Note that the brown dots are "reported" values under the conservative approach from the same source, while the red crosses aggregate overall revenues and costs values we have for each respective country.[305]

Figure 19: Costs per tkm by country



[303] Note that Austria is an exception, where we observe aggregated revenues (excl. subsidies) since this is clearly stated in the Rail Cargo annual report (2019).
[304] This time period is applicable to the presentation results of costs, revenues and profitability for all dimensions.
[305] This is applicable for all presentation results of costs, revenues and profitability.

Source: The Consortium based on publicly available sources and stakeholder consultation. Note that we have no cost data for France.

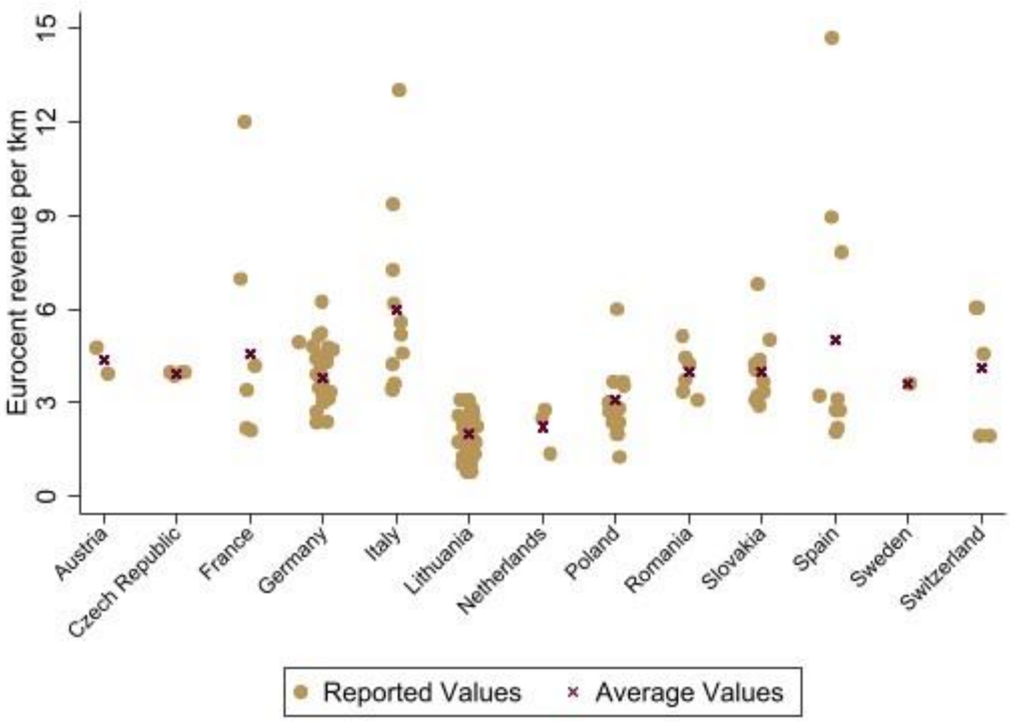
We make the following observations regarding average costs in the rail freight sector:

- The range of average costs per tkm by country spans between approximately 2 cent/tkm and 6 cent/tkm. [306]
- Overall, we observe high costs in Austria, Germany and Switzerland. To some extent, this may be influenced by geographical factors, with increased costs being due to advanced infrastructure to facilitate rail freight in mountainous regions.
- We also observe that most of the other countries' average costs lie below 4 cent/tkm.
- The reported costs are relatively dispersed (with a wide range) in Austria, Germany, the Netherlands and Switzerland, and similar (within a rather small range) in Poland, Slovakia and Spain. However, these results should be interpreted with caution, as for some countries, we just only a single data point (for example, the Czech Republic, Italy, Lithuania, Romania and Sweden).

Please refer to Annex 22.1 for an equivalent graph showing reported costs and the respective ranges.[307]

Figure 20 provides the reported revenues as well as average revenues (represented by red crosses) of the rail freight sector for each country across all other dimensions, sources and applicable time periods.

Figure 20: Revenues per tkm by country



Source: The Consortium based on publicly available sources and stakeholder consultation. Note that we have considered the outliers and rendered them as valid due to the reasons described in more detail below.

We make the following observations regarding average revenues of the rail freight sector by country:

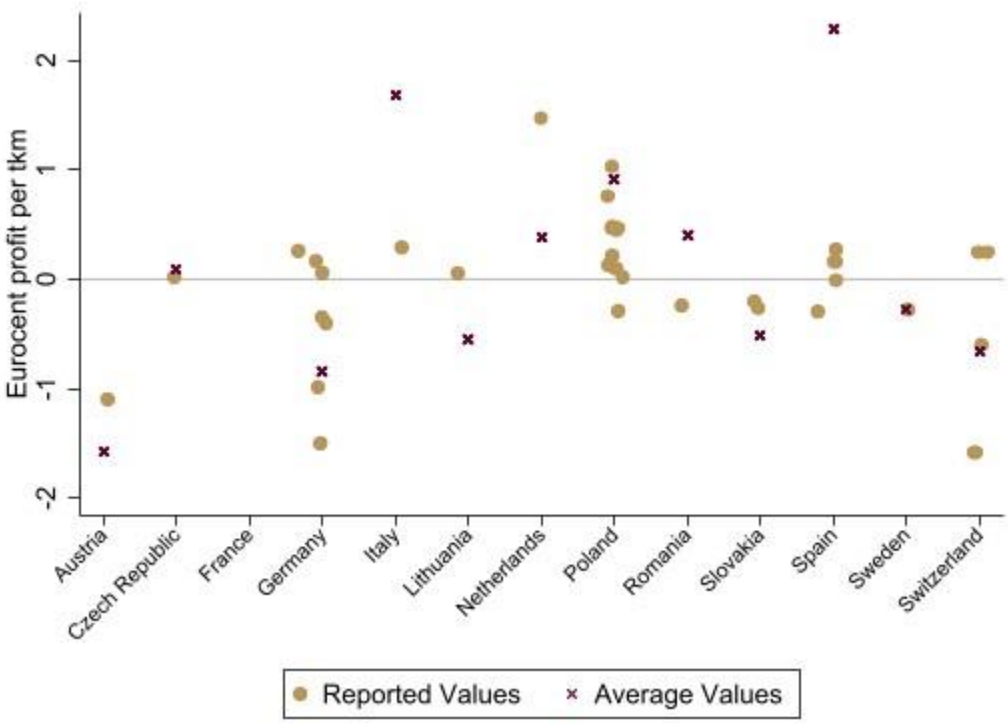
[306] The summary estimates presented as part of the results are rounded off to the nearest unit.
[307] The graphs in the annex comprise of box plots showing just the reported values and the respective ranges of the reported values, and no average values.

- The range of average revenues per tkm by country spans between approximately 2 cent/tkm and 6 cent/tkm.
- We observe outliers that drive the higher average revenues in Italy, France and Spain. Railway undertakings that qualified as outliers could be using train types and transporting freight categories that are high-revenue yielding. For example, automotive and chemicals (see Section 4.2.5).
- Like with costs, the reported revenues are relatively dispersed (with a smaller range) in Germany and Switzerland.

Please refer to Annex 22.1 for an equivalent graph showing reported revenues and the respective ranges.

Figure 21 provides the reported profits as well as average profits (represented by red crosses) of the rail freight sector for each country across all other dimensions, sources and applicable time periods.

Figure 21: Profits per tkm by country



Source: The Consortium based on publicly available sources and stakeholder consultation.

We make the following observations regarding profitability of the rail freight sector by country:

- The range of average profits per tkm by country is between approximately -2 cent/tkm and 2 cent/tkm.
- Reported values for the Czech Republic, Lithuania and Spain suggest they are operating at near-zero margins or close to breaking even. However, on average Lithuania is loss-making, and Spain seems profitable. See details below.
- Reported values for Austria, Germany, Romania, Slovakia, Sweden and Switzerland suggest they are loss-making. However, on average Romania seems profitable. See details below.
- Italy, Netherlands and Poland are clearly more profitable than the other countries.[308]

[308] Note that in the Netherlands there is a clear outlier of a very high profitability reported in the Stakeholder consultation.

- The reported profits are more dispersed (with a wider range) in Germany, the Netherlands and Switzerland.
- We note that the average estimates are higher or lower than the reported figures in the case of some countries. In these cases, the "average" values are driven by either (i) higher average costs (thereby reporting a lower average profit) and the absence of corresponding revenue data or (ii) high revenues (thereby reporting a higher average profit) and the absence of corresponding cost data. See Annex 22.1
- However, these results must be interpreted with caution since we have limited data and the validity of such conclusions may benefit from a larger sample, or simply more data on the different dimensions.

Please refer to Annex 22.1 for an equivalent graph showing reported profits and the respective ranges.

Table 14 provides average costs and revenues per tkm in selected countries:

Table 14: Average cost, revenues and profitability by country

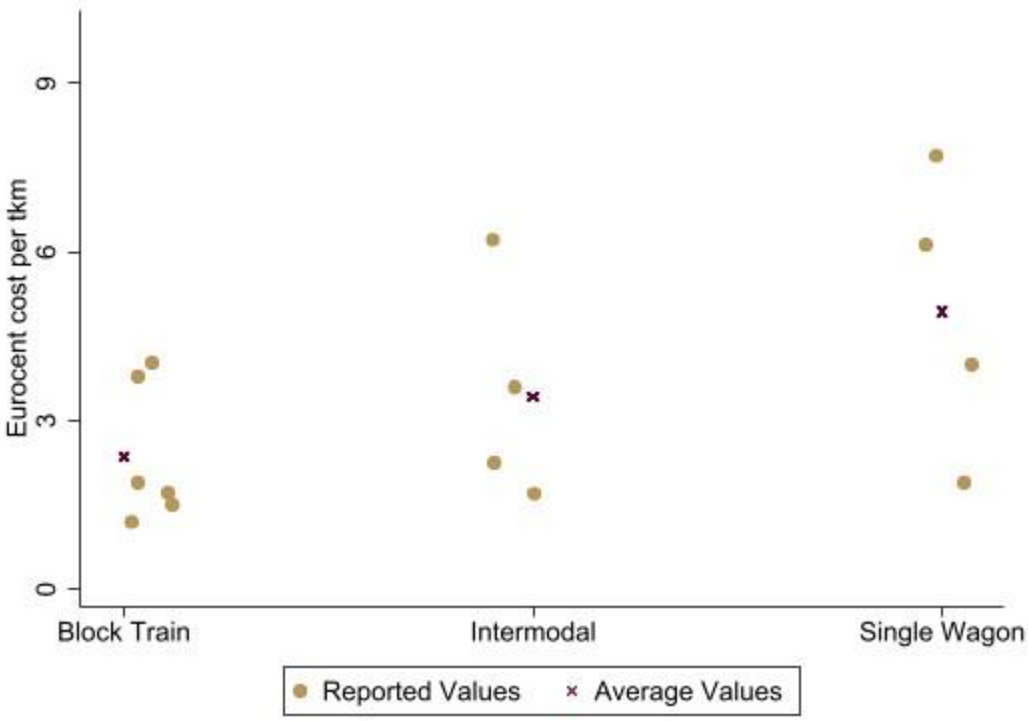
Country	Cost (€cent/tkm)	Revenue (€cent/tkm)	Profitability (€cent/tkm)
Austria	5.94	4.37	-1.57
Czech Republic	3.86	3.95	0.09
France	N/A	4.59	N/A
Germany	4.63	3.79	-0.84
Italy	4.31	6.00	1.69
Lithuania	2.55	1.99	-0.56
Netherlands	1.85	2.23	0.38
Poland	2.20	3.11	0.91
Romania	3.62	4.01	0.39
Slovakia	4.48	3.97	-0.51
Spain	2.77	5.04	2.28
Sweden	3.92	3.64	-0.28
Switzerland	4.78	4.13	-0.65

Source: The Consortium based on publicly available sources and stakeholder consultation. Estimates represent simple averages across all dimensions and sources for the period 2015 – 2020, by country. Note that in some cases the average profitability is higher/lower than reported values, which drives the profitability estimates. For example, Austria, Lithuania, Italy, Slovakia, Romania and Spain. See Annex 22.1 for more details.

4.2.3 Train types

Figure 21 provides the reported costs as well as average costs (represented by red crosses) for each train type across all other dimensions and all available sources and applicable time periods.

Figure 21: Costs per tkm by train type



Source: The Consortium based on publicly available sources and stakeholder consultation.

We make the following observations regarding costs of train types:

- The range of average costs per tkm by train type is between approximately 2 cent/tkm and 5 cent/tkm.
- The cost of single-wagon transport is higher compared to both block trains and intermodal transport. The difference is characterised by the high fixed costs of making required infrastructure available and keeping it maintained, as well as the costs associated with assembly at shunting and marshalling yards. The Box below discusses single-wagon transport in more detail.
- Block trains incur a lower average cost compared to both intermodal and single-wagon transport, and are therefore considered to be the most competitive among the different train types.
- The reported costs are more dispersed (with a wider range) in the case of single-wagon transport and intermodal transport, than for block trains.

Please refer to Annex 22.2 for an equivalent graph showing reported costs and the respective ranges.

Table 15 summarises the average cost differences between train types by country.

Table 15: Cost comparison of train types by country

Country	Block train Cost (€ct/tkm)	Intermodal Transport Cost (€ct/tkm)	Single-Wagon Cost (€ct/tkm)	Ratio (IM to BT)	Ratio (SW to BT)
Austria	3.79	6.22	7.72	164%	204%
Germany	4.03	3.59	6.13	89%	152%

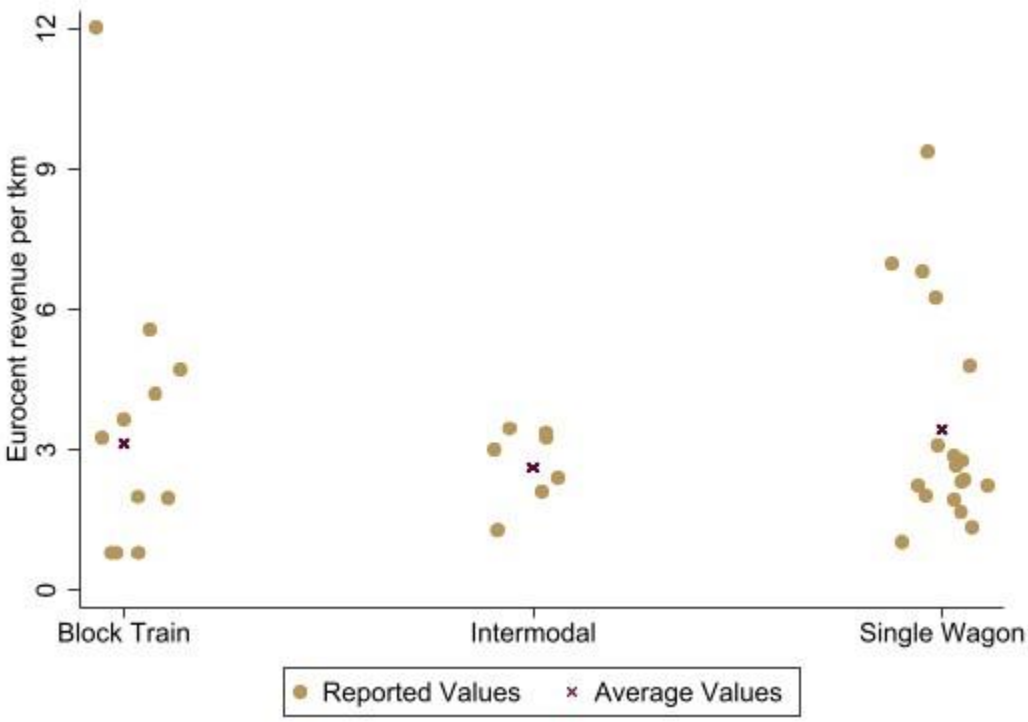
Netherlands[309]	1.35	1.70	4.00	126%	296%
Poland	1.90	2.25	1.90	118%	100%
Austria (Economica 2013)*	-	-	-	-	172%
Europe (de Jong et al. 2016)**	3.1	2.8	4.6	89%	148%

Source: The Consortium based on reported: Herry Study (2020), VDV Association Market Report (2020), Panteia (2020), Lotos Survey (2019), Economica (2013), Europe (de Jong et al. 2016).

The estimates are calculated as simple averages over all available data points, broken down by train type and countries. Costs per tkm are highest for single-wagon transport, with the exception of Poland.[310] Block train and intermodal transport are at a similar level. Part of the variation in costs may be due to differences in the methodologies used to compute costs.

Figure 22 provides the reported revenues as well as average revenues (represented by red crosses) for each train type across all other dimensions and all available sources and time applicable periods.

Figure 22: Revenues per tkm by train type



Source: The Consortium based on publicly available sources and stakeholder consultation.

We make the following observations regarding revenues of train types:

- The range of average revenues per tkm by train type spans between approximately 3 cent/tkm and 4 cent/tkm.

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309 Panteia (2020) assigns freight categories to either liquid and dry bulk that are transported by shuttle services, general cargo and containerised transport. The costs of shuttle services, which we interpret as block trains, are further split by the type of cargo.
310 Non-Incumbent Lotos Survey (2019).

- In line with costs, single-wagon operations tend to yield higher average revenues compared to the other two train types.
- The variation in revenues of different train types is lower than the respective variation of costs. The revenues are typically determined by demand and competitive pressure within the rail sector or from road transport, which affect intermodal transport and single-wagon transport in a similar way, while block trains may have an advantage over the other train types for bulk freight and high volumes.
- The reported revenues are more dispersed (with a wider range) in the case of block trains and to a lesser extent single-wagon transport compared to intermodal transport. This suggests that the pricing for intermodal transport is more homogenous than that for other train types. This could reflect differences in the level of intra-modal competition across countries.

Please refer to Annex 22.3 for an equivalent graph showing reported revenues and the respective ranges.

Table 16 summarises the revenue differences between train types.

Table 16: Revenue comparison of train types

Country	Block Train Revenue (€ct/tkm)	Intermodal Transport Revenue (€ct/tkm)	Single-Wagon Revenue (€ct/tkm)	Ratio (IM to BT)	Ratio (SW to BT)
France	6.84	1.96	6.86	29%	100%
Germany	3.98	2.69	5.28	68%	133%
Italy	5.57	3.46	9.37	62%	168%
Lithuania	0.78	1.28	2.28	165%	294%
Poland	2.00	3.01	2.37	150%	118%
Slovakia	3.23	3.44	6.72	107%	208%

Source: The Consortium based on publicly available sources and stakeholder consultation. Estimates represent simple averages across all dimensions and sources for the period 2018 – 2020, by country.

Revenues per tkm for single-wagon train types are much higher, relative to block trains, compared to intermodal transport. In line with Table 15 it is fairly easy to see how higher costs motivate higher revenues in the case of single-wagon transport.

Given the limited data availability on both costs and revenues and inconsistency in reporting methodologies for the same country, we do not report profitability figures. Instead, we report average costs and revenues for different train types per country.

SINGLE-WAGON

Single-wagon transport volumes are in decline across Europe (PWC et al. 2015). There are multiple, complementary explanations for this trajectory, but two reasons are particularly salient. First, single-wagon transport faces significant competition from road and intermodal transport. Trucks and intermodal transport chains also offer door-to-door services, but with faster and more reliable delivery times, often at a lower price (XRail interview). Second, single-wagon operations are heavily reliant on an efficient infrastructure and the availability of rolling stock. Historically, many national incumbents set up single-wagon transport systems and benefitted from economies of scope due to their dense railway network and a multitude of shunting and marshalling yards, as well as a high number of private sidings that were connected to the main network. However, the available infrastructure declined in many MS (see e.g. PWC et al. 2015, Bundesnetzagentur 2022, p.33). Availability of and access to such infrastructure is often limited.

Most of the remaining major players in Europe are members of Xrail, an alliance dedicated to improving single-wagon competitiveness vis-à-vis road, especially on cross-border routes.[311] However, single-wagon infrastructure is in decline;[312] some incumbents have even opted to discontinue their single-wagon operations.[313] Market liberalisation merely induced some incumbents from other countries to enter new national markets (Bundesnetzagentur 2022, p.30). There are only few independent RU that offer single-wagon transport. Examples include Lotos in Poland or Chemion in Germany. These tend to operate in small, regional networks, and ship freight which cannot be easily transported by trucks, e.g. in clusters of chemical industry. Bundesnetzagentur (2022) distinguishes between RU that offer full-distance, doort-to-door single-wagon transport and regional subcontractors that only perform parts of the transport chain. In particular, the former often subcontracts the haulage of first and last mile to the latter.[314] However, other large players such as SNCF prefer to organise the first and last mile operations within their organisation (OFP interview). Annex 24 provides case studies of small, regional RU of which some offer single-wagon transport.

While there is generally very little quantitative evidence on the costs and revenues of single-wagon operations, stakeholder interviews (e.g. Xrail interview. SNCF interview) and further available evidence indicate that the cost structure of single-wagon transport differs substantially from other train types. Single-wagon transport is a system that requires long-term investment in infrastructure and rolling stock.[315] Consequently, fixed costs are high, likely too high to be fully recuperated. Additionally, precise cost calculations for a specific single-wagon transport are frequently difficult to obtain (Interview SNCF and Bundesnetzagentur 2022). Maintaining the overall single-wagon network represents a large share of the costs of single-wagon operations. These shared costs, including many small terminals, sidings and marshalling yards with the relevant rolling stock, are difficult to attribute to individual single-wagon services. This specific cost structure with a large share of fixed costs and at the same time a large share of shared costs with other train types makes bottom-up calculations of the costs of single-wagon operations unreliable. The high share of fixed costs implies that operations, if at all, can only be profitable if network utilisation and freight volumes and service frequencies are high. However, achieving high utilisation rates proves to be difficult in reality. In fact, wagons are often retrieved empty after delivery (Xrail interview).

The exhibits in Section 4.2.3 illustrate the high range of costs and revenues in single-wagon transport. Both are generally higher than for block trains or intermodal transport. Most estimates fall into a range between 2-7 cent/tkm. Similarly, Bundesnetzagentur (2022) provides a cost range of 5-8 cent/tkm for German full-distance single-wagon operators. Generally, costs seem to exceed revenues, rendering the sector as a whole unprofitable (VDV interview, Xail interview, KSW interview and other stakeholder feedback). This is echoed in Bundestnetzagentur (2022) reporting a sector-wide return on sales of -14.5% for 2019, although a minority of operators is profitable. Moreover, the subcontractors providing short-distance operations are overall cost-covering.

For single-wagon operations, the cost share of the main leg is relatively small in relation to its significance in transport distance. Bundesnetzagentur (2022, p.31) reports that on German single-wagon transports, the main leg makes up 88% of total transport distance on average, but only 55% of costs. Instead, it is the assembly at shunting and marshalling yards (25%) as well as the feeder and distribution legs (20%) that disproportionally drive single-wagon costs.

[311] The seven members are the incumbents of Luxembourg, Germany, France, Sweden, Belgium, Austria and Switzerland. Together, they account for roughly two thirds of single-wagon transport across Europe (XRail interview). Interestingly, about two thirds of single-wagon transports are international connections (PWC et al. 2015).

[312] PWC et al. (2015, p.45 & p.55) highlight the failure of key stakeholders to invest in private sidings and marshalling yards. The Czech Republic, for instance, aimed at closing 70% of its private sidings Refer to Section 2.5 for a more detailed description of the decline in private sidings. Similarly, the number of marshalling yards declined in many European countries.

[313] Among the more prominent examples are *Mercitalia*, *Renfe*, and *PKP Cargo*. Generally, there are market exit barriers and scaling down operations likely renders operations less profitable.

[314] Bundesnetzagentur (2022, p.33) assesses that first and last mile services require different resources (e.g. locomotives and personnel).

[315] Building a private siding is a lengthy and expensive undertaking that usually does not pay off without State Support (see Section 2.5). Sometimes, co-located customers may opt to jointly invest into access to the rail network. Public loading points are rare and remove the door-to-door advantage of single-wagon transport.

Likewise, they drive total transport time (Bundesnetzagentur 2022, p.32).[316] The quality and availability of short-distance rail services, i.e. shunting and local distribution, varies across countries. In some Member States, supply of such services is characterised by insufficient access and/or prohibitively expensive pricing.

The stakeholder consultation seems to confirm that conditions vary across Member States.[317] Annex 26 summarises responses from market regulators regarding the supplier structure, incumbent market shares and service levels of local distribution services as well as marshalling and shunting operations. The supplier structure is diverse, and the incumbent's market share varies from about 45% to virtually 100%. All regulators regard the availability of and access to marshalling and shunting services as medium to good. There were only two responses regarding distribution services, but those also indicated good availability and access.[318]

So far, this section has painted a somewhat bleak outlook for the future of single-wagon transport, and this extends to its competitiveness with other transport modes. Indeed, some stakeholders argue that intermodal transport represents an economically viable, more flexible multi-client solution that will continue to cannibalise traditional door-to-door single-wagon systems, making them largely obsolete in the long-term. On the other hand, proponents insist that the main competitor is road and single-wagon operations are complementary to intermodal transport and are preferable in certain circumstances (XRail interview). Without taking a definitive stance on the future of single-wagon operations, it is useful to consider the circumstances under which it is a viable, though potentially niche, business.

Single-wagon transport may often be the preferred choice for a firm if it has easy access to a (typically private) siding. This is an important precondition: As reported in Section 2.5, private sidings are a substantial investment with high maintenance requirements. While such investments can be justified by the prospect of regularly deployed block trains, mere single-wagon operations often do not recuperate the investment costs. A similar argument applies to investments in rolling stock, especially digital automated coupling (DAC) technology. Recall from Section 3.5 that DAC has the potential to drive down operating costs, accelerate train assembly, and increase train lengths substantially. Nevertheless, given the requirement of a comprehensive adoption of DAC, it is unclear whether unilateral investment would be immediately recuperated without State support.

When assessing the merit of a private siding against using publicly accessible intermodal terminals in an intermodal transport chain, the density of those terminals may constitute a crucial factor. If the next intermodal terminal is far away from a customer's plant, that customer is likely to be more inclined to opt for a private siding in order to ensure immediate access to the railway network. Similarly, the connectivity of intermodal terminals may be important. As density increases, more terminals will have low freight volumes, where frequent point-to-point shuttle connections are unlikely to be efficient. Instead, single-wagon style operations could forward single or small groups of wagons to intermediate locations and reassemble them.[319] In these cases, railway undertakings would realise further economies of scope from existing single-wagon operations.

Large railway undertakings could also justify maintaining a single-wagon network for the benefits they provide to other operations. Single-wagon locomotives are sometimes used to transport empty wagons that will become part of another train type, say a block train, or to transport damaged rolling stock to repair facilities. To that end, single-wagon entails economies

[316] Bundesnetzagentur (2022) also provides a cost split of cost items. According to this source, rolling stock and labour costs account for a high share of single-wagon operators' total costs, followed by track access charges and energy costs.
[317] See also the highlighted differences in the number of RU across countries in Table 3 and the supplier structure of short-distance services in Section 4.4.3.
[318] A (single) response from an infrastructure manager considers availability and access to marshalling and shunting operations be very good. However, the response also indicates that prices are too low to be profitable. Most RU assign high importance to those services, especially for single-wagon transport. Their assessment of availability and access is mixed. Interestingly, all RU indicate that they typically provide marshalling and shunting themselves.
[319] Annex 26 also discusses single-wagon transport of intermodal loading units. Here, feeder legs to and distribution services from intermediate marshalling locations are conducted by single-wagon transport *and* trucks. This service may have potential to shift substantial volumes from road to rail because it does not compete with high-volume intermodal shuttle connections between metropolitan hubs, but still attracts customers that do not have access to a private siding. Please note that this kind of service does not unambiguously fit the classification of train types adopted in this paper.

of scope that support general operations (Xrail interview). Similarly, single-wagon may contribute to covering fixed costs that otherwise only block trains and intermodal transport operations would bear.

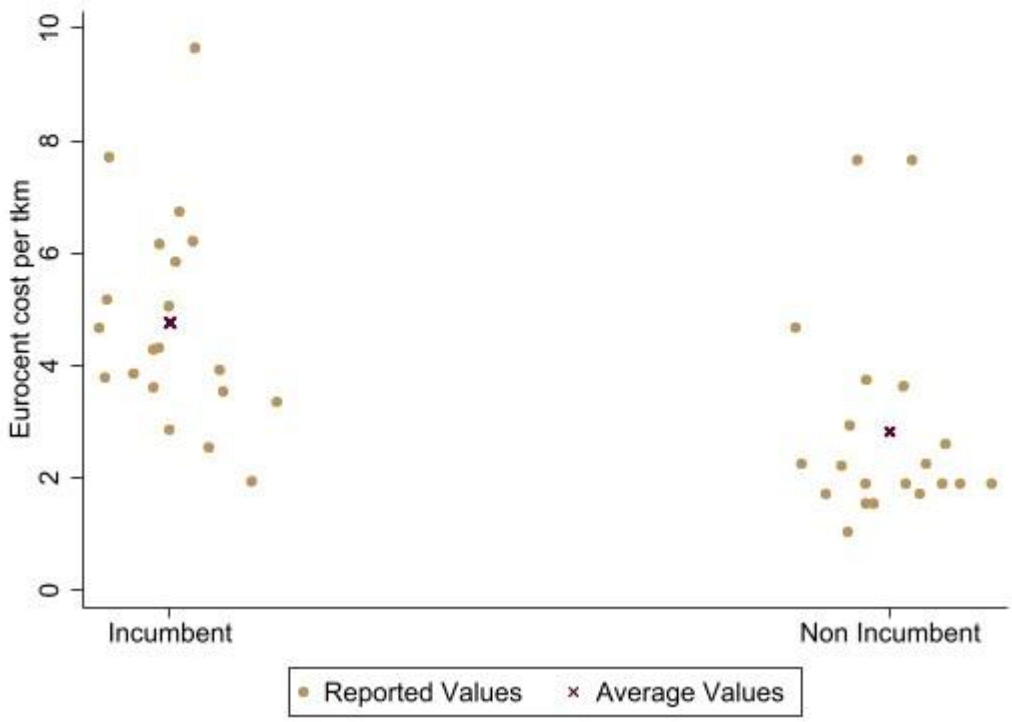
Based on the types of freight that are typically transported in single-wagon operations, they may have a competitive advantage over intermodal transport for heavy goods (Xrail interview). Rail wagons can exploit volume effects and load more weight on one wagon than on a truck.

To conclude, our data as well as qualitative evidence indicate that single-wagon operations are overall unprofitable.[320] High network and investment costs paired with low utilisation rates, longer transport times and unsatisfactory reliability render it mostly uncompetitive against road and intermodal transport. However, operating a single-wagon system in a specific freight segments (chemicals) or under specific circumstances (high performance infrastructure, modern rolling stock) may be profitable.

4.2.4 Market participants

Figure 23 provides the reported costs as well as average costs (represented by red crosses) for each market participant type across all other dimensions and all available sources and applicable time periods.

Figure 23: Costs per tkm by market participant type



Source: The Consortium based on publicly available sources and stakeholder consultation.

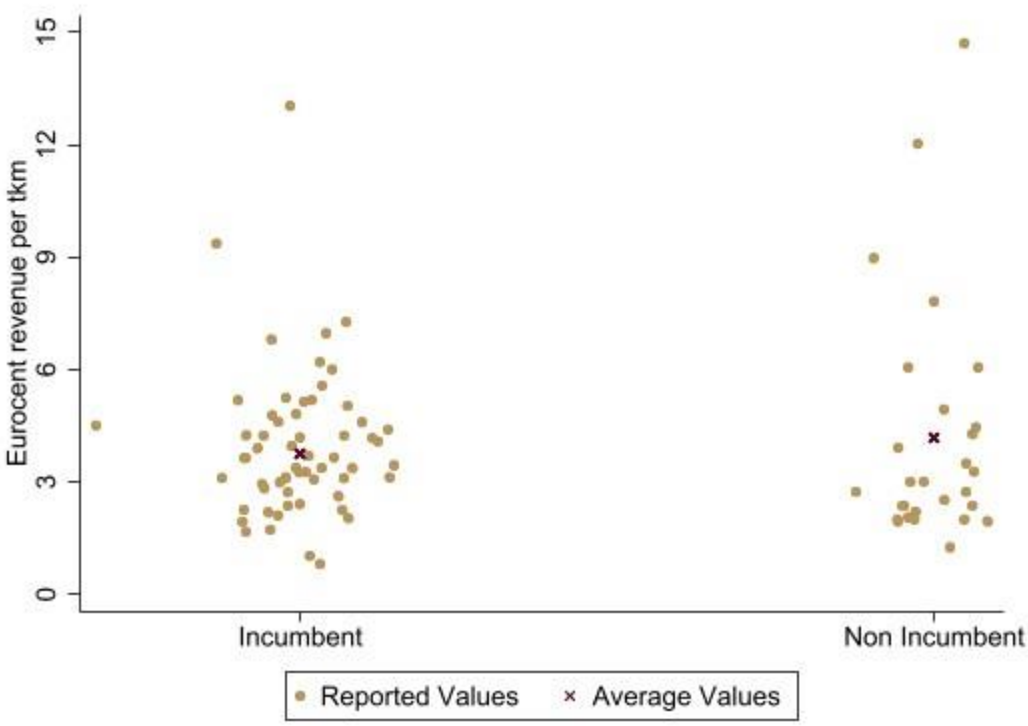
The range of average costs per tkm by market participant is between approximately 3 cent/tkm and 5 cent/tkm. The reported costs per tkm are more dispersed (with a wider range) in the case of incumbents, compared to non-incumbents. Moreover, it is observed that incumbents generally incur higher costs compared to non-incumbents. This could be explained by the differences between certain cost items like labour costs, where incumbents often face stronger pressure from unions. Furthermore, in many countries, incumbents are the primary market players carrying out single-wagon operations, which drives their average costs high.

320 See Section 4.8.1 for a brief discussion on the role of subsidies in making single-wagon transport profitable.

Please refer to Annex 22.3 for an equivalent graph showing reported costs and their respective ranges.

Figure 23 provides the reported revenues as well as average revenues (represented by red crosses) for each market participant type across all other dimensions and all available sources and applicable time periods.

Figure 23: Revenues per tkm by market participant type



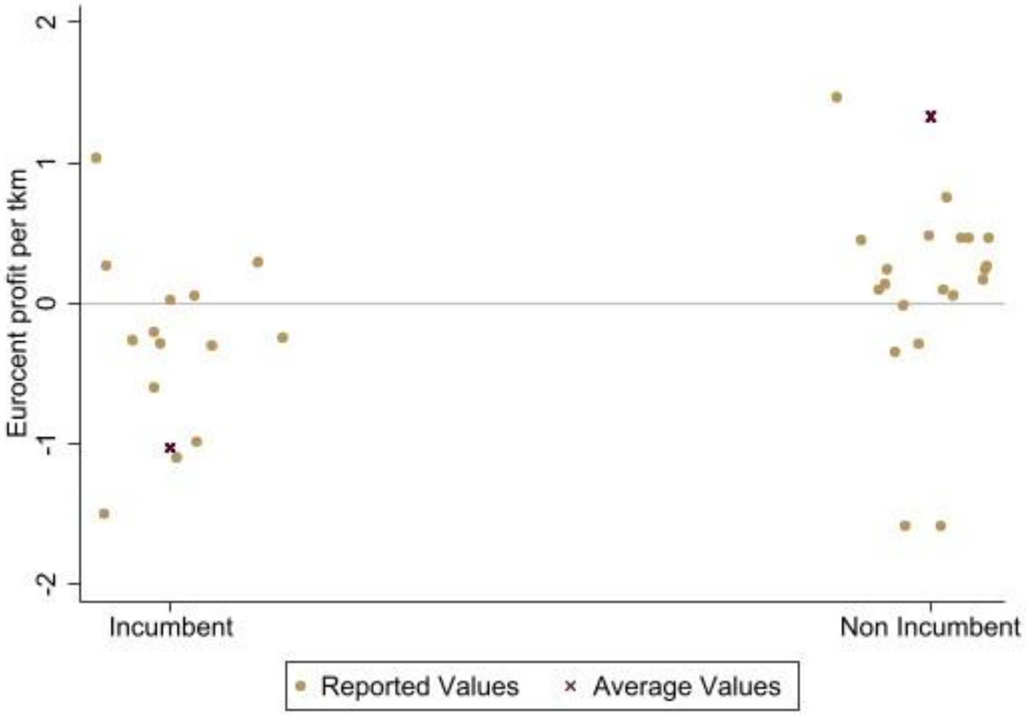
Source: The Consortium based on publicly available sources and stakeholder consultation.

The range of average revenues per tkm by market participant is between approximately 3 cent/tkm and 4 cent/tkm. The reported revenues per tkm are more dispersed in the case of non-incumbents, compared to incumbents. More generally, we observe that non-incumbents also earn higher revenues. This could be driven by the high revenues we observe for certain dimensions (for example, higher-revenue yielding freight categories such as automotive equipment). Moreover, when compared to the cost structure, we observe limited variation in the revenues earned by the market participants. Note that it is not surprising that incumbents and non-incumbents realise similar revenues in a competitive market.

Please refer to Annex 22.3 for an equivalent graph showing reported revenues and the respective ranges.

Figure 24 provides the reported profits as well as average profits (represented by red crosses) for each market participant type across all other dimensions and all available sources and time periods.

Figure 24: Profits per tkm by market participant



Source: The Consortium based on publicly available sources and stakeholder consultation.

We make the following observations regarding revenues earned by the different market participants:

- The range of average profits per tkm by market participant is between -1 cent/tkm and 1 cent/tkm. The reported profits per tkm are more dispersed in the case of incumbents, compared to non-incumbents.
- On average, the incumbents are loss-making when compared to the non-incumbents.
- The discrepancy between the profitability of incumbents and non-incumbents is largely driven by high incumbent costs.
- Furthermore, it is not surprising that non-incumbents tend to be profitable. They chose to enter the market and can select profitable routes. Also, the sample of non-incumbents might be subject to self-selection as market exit should be easier for non-incumbents.

Please refer to Annex 22.3 for an equivalent graph showing reported profits and the respective ranges.

4.2.5 Freight categories

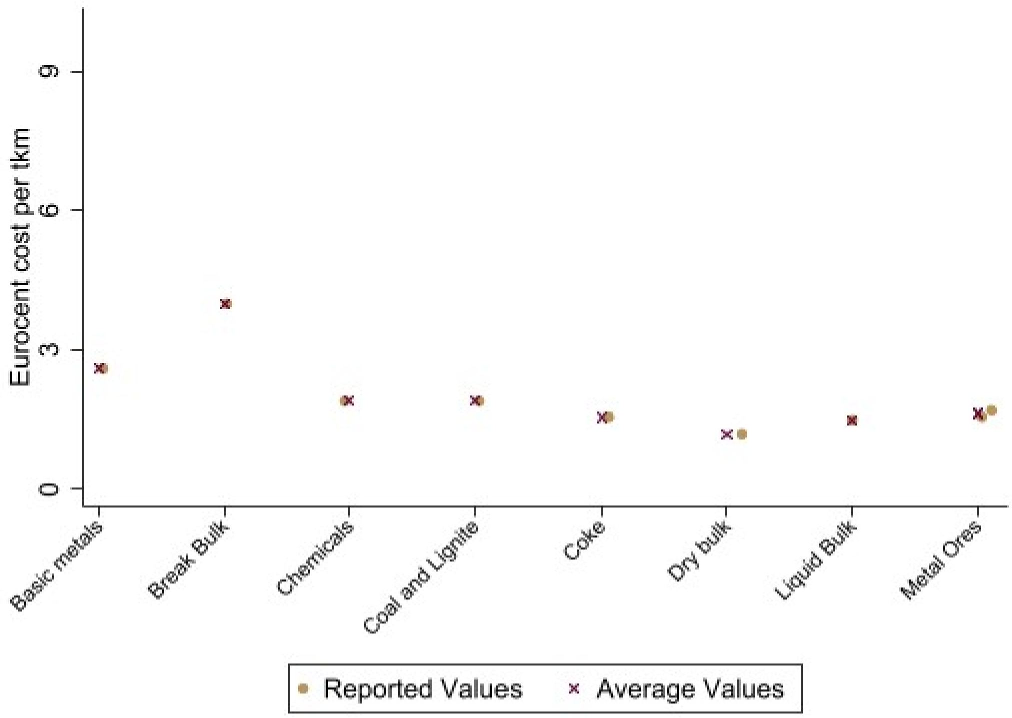
Figure 25 provides the reported costs as well as average costs (represented by red crosses) for each freight category across all other dimensions and all available sources and applicable time periods. Note that Panteia (2020) uses the following categorisation to identify freight moved: dry bulk, liquid bulk and break bulk. Further, Panteia (2020) provides the following mapping to the Dutch 'BasGoed' categorisation:[321]

- Dry bulk: Agricultural and food products; Coal, brown coal and cokes; Ores; and Salt, sand, gravel and clay.
- Liquid bulk: Crude oil and natural gas; chemical products and miscellaneous minerals.

[321] 'BasGoed' refers to the strategic freight transport model in the Netherlands. See also Panteia (2020), p.8., Figure 2.1. Note that this is similar to the NST (2007) categorisation.

- Break bulk: Miscellaneous goods and base metals and metal products.

Figure 25: Costs per tkm by freight category



Source: The Consortium based on publicly available sources and stakeholder consultation.

We make the following observations regarding costs by freight categories transported:

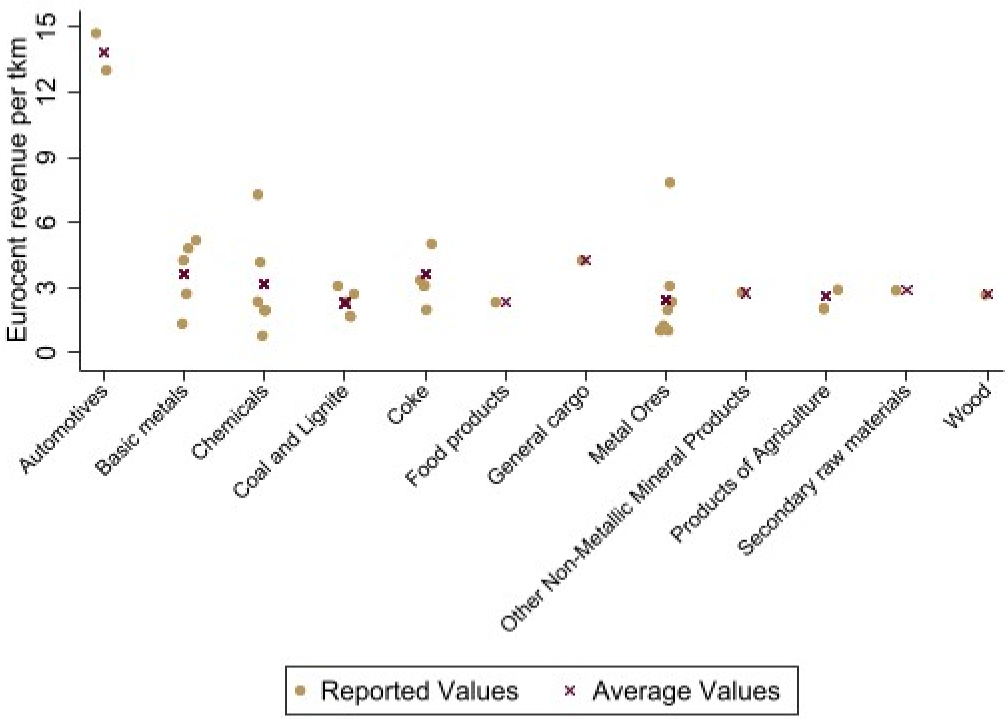
- The range of average costs per tkm by freight category is between 1 cent/tkm and 4 cent/tkm.
- With the exception of break bulk, the range of estimates is fairly low. This supports the intuitive conjecture that the type of freight typically does not have a significant impact on costs. Some of the observed heterogeneity across freight categories could be explained by the train type that typically hauls the freight categories.
- Break bulk is comprised more of base metals and metal products than heavier goods in general. Moreover, it also includes of miscellaneous goods which are transported using single-wagon transport. This may help explain why it is also the costliest freight category in terms of the costs incurred.[322]

Please refer to Annex 22.4 for an equivalent graph showing reported costs and the respective ranges.

Figure 26 provides the reported revenues as well as average revenues (represented by red crosses) for each freight category across all other dimensions and all available sources and applicable time periods. Note that we have more data available for revenues pertaining to different freight categories than for costs.

[322] Panteia (2020), p.55, Table 6.2.

Figure 26: Revenues per tkm by freight category



Source: The Consortium based on publicly available sources and stakeholder consultation.

We make the following observations regarding revenues by the type of commodity transported:

- The range of average revenues per tkm by freight category is between 2 and 14 cent/tkm.
- The reported revenues per tkm are more dispersed for chemicals, basic metals and metal ores, compared to the other freight categories.
- Compared to costs, revenues show higher variation across freight categories. This indicated that RU are able to charge higher prices for some types of goods:
  - Automotive goods incur the highest revenue among the different categories. This is mostly driven by catering to special requirements to transport heavy and bulky goods in the automotive industry, which cannot be easily provided by road.
  - Basic metals are not only the second most costly freight category, but are also among the high revenue-yielding freight categories.
  - Chemicals and coke may have certain chemical properties (potentially risky and hazardous) that in turn require specific conditions under which they must be transported. Regulations may even require chemicals to be transported by rail. All this lessens competition from other transport modes and hence may allow to achieve relatively higher revenues.

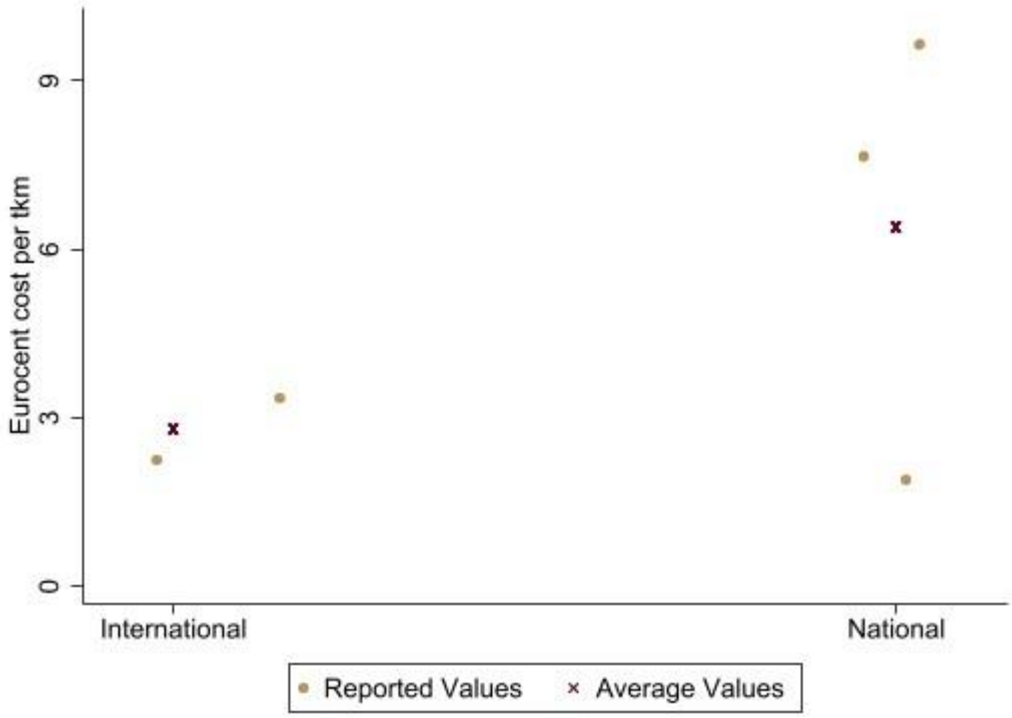
Please refer to Annex 22.4 for an equivalent graph showing reported revenues and the respective ranges.

Given the limited data availability on both costs and revenues as well as inconsistencies in reporting methodologies and classification systems, we do not report profits for the different freight categories.

4.2.6 National/international scope

Figure 27 provides the reported costs as well as average costs (represented by red crosses) for trains by national or international[323] routes, across all other dimensions and all available sources and applicable time periods.

Figure 27: Costs per tkm by national/international scope



Source: The Consortium based on publicly available sources and stakeholder consultation.

We make the following observations regarding costs by national/international routes:

- The range of average costs per tkm by international or national scope is between 3 cent/tkm and 6 cent/tkm.
- On average, higher costs are incurred on national routes, compared to international rail freight transport.
- Generally, there are two major opposing effects that moderate the cost differences between national and international transport. First, crossing borders entails additional costs (see Section 4.5). Based on that reasoning, international transport would be costlier than national. The second, opposing effect is that international transport distances tend to be higher than their domestic counterparts. As Section 4.3 outlines, longer distances involve lower average unit costs. Ceteris paribus, this would in turn suggest that international transport costs lower than those for national transport. Which effect dominates, depends on a number of circumstances, many of which are country-specific.
- The reported costs per tkm are more dispersed for the national scope, compared to the international scope. The dispersion may be influenced by the relationship between distance travelled within the national scope and the size of the country. For example, a small country implies shorter domestic trips. Conversely, a larger country's domestic trips maybe much longer. In line with this, smaller countries may see high costs, while the larger countries may see low costs for the national scope of rail freight transport. In general, international rail freight services are

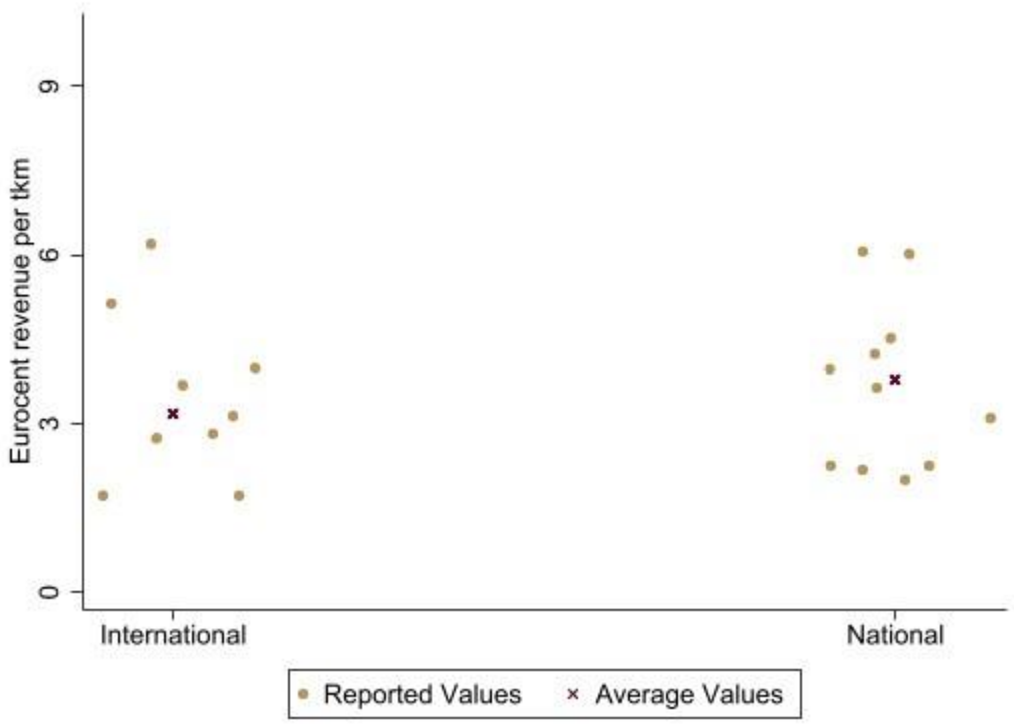
[323] We define international transport as any train journey where at least one border is crossed. This includes imports, export and transit.

offered by fewer RU due to the cross-border challenges, where there are country-specific requirements for RU to operate (for example, safety certificates). [324] On average: Poland and Austria seem to charge similar prices for international transport. However, as we will see in Section 4.3, specific costs may vary depending on the difficulty encountered at crossing borders.

Please refer to Annex 22.5 for an equivalent graph showing reported costs and the respective ranges.

Figure 28 provides the reported revenues as well as average revenues (represented by red crosses) for trains by national or international routes, across all other dimensions and all available sources and applicable time periods.

Figure 28: Revenues per tkm by national/international scope



Source: The Consortium based on publicly available sources and stakeholder consultation.

We make the following observations regarding revenues by the national/international routes:

- The range of average revenues per tkm by national/international routes is between 3 cent/tkm and 4 cent/tkm.
- Unlike costs, the differences in revenues between national and international freight trains are limited.
- The reported revenues per tkm are more dispersed for international rail freight transport, compared to those of national scope.
- The dispersion in revenues or prices charged for international rail freight services may be influenced by the number of RU offering international transport and the level of competition in specific routes. For routes where there is increased competition, RU may offer lower prices in the interest of being more competitive with the alternatives and conversely, for routes where there are a limited number of RU offering such services and the demand is inelastic to some extent, the prices charged maybe higher.

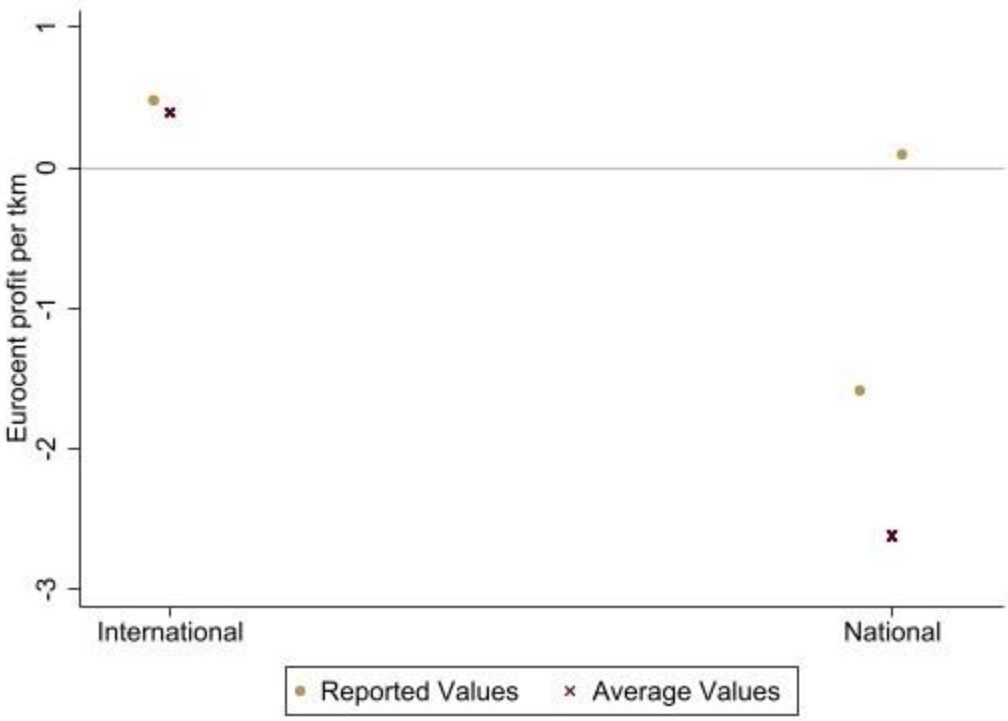
[324] RU that meet the requirements necessary for the safe performance of railway transport services within a given railway network, receive a safety certificate that is valid only in the country where it was issued.

- For example, in Baltic countries like Lithuania and Estonia, there is intense competition among RU for transit freight originating from Russia (Koppel, 2006). As a result, prices of international rail freight services maybe lower for these countries.

Please refer to Annex 2.5 for an equivalent graph showing reported revenues and the respective ranges.

Figure 29 provides the reported profits as well as average profits (represented by red crosses) for trains, by national or international routes, across all other dimensions and all available sources and time periods.

Figure 29: Profits per tkm by national/international scope



Source: The Consortium based on publicly available sources and stakeholder consultation.

We make the following observations regarding profits by national/international routes:

- In line with the costs and revenues, we see that on average international freight transport seems to be more profitable than national freight transport.
- This corroborates the conjecture that longer journeys may typically bring in greater economies of scale and make freight transport more cost-efficient.
- While these results are mainly reported in publicly available sources and in line with stakeholder consultation, we extrapolate by modelling cross-border costs in Section 4.5.
- The range of average profit per tkm by national/international routes is between -3 cent/tkm and 0.4 cent/tkm.
- The reported profits per tkm are more dispersed for the international rail freight transport, compared to those of national scope. As discussed earlier, dispersion in revenues for the international scope may be the underlying driver of dispersion in profitability for the international scope.

Please refer to Annex 22.5 for an equivalent graph showing reported revenues and the respective ranges.

CONCLUSIONS:

Regarding the profitability of rail freight, countries can be grouped into in three categories:

- Operating at near-zero margins or breaking even: reported values for the Czech Republic, Lithuania, and Spain suggest they are operating at near-zero margins or close to breaking even;
- (ii) loss-making: Austria, Germany, Romania, Slovakia, Sweden, and Switzerland are loss-making; and
- (iii) profitable: Italy, the Netherlands and Poland are more profitable than other countries.

Regarding other dimensions, we observe that:

- Non-incumbents are generally more profitable than incumbents.
- Single-wagon transport has higher costs than block trains and intermodal transport.
- In general, variation in revenues pertaining to different freight categories is higher compared to costs, that remain fairly uniform. We observe that automotive equipment and metal ores, often bulkier and heavier than other goods, earn high revenues.
- International rail freight transport is on average more profitable than national transport.

4.3 Simulation of the effect of changes in train length and distance on costs and revenues

4.3.1 Methodology, data and limitations

In this Section, we simulate changes in the costs and revenues per net tonne-kilometre of a train service that is driven by increases in average distance travelled and in average train length. Following such changes, we present evidence indicating an increase in competitiveness

The input variables required for the simulation are (i) variable cost shares, (ii) average distance travelled and (iii) average train length. To this end, we first identify cost items that are variable, i.e. distance-dependent (energy, track access charges and variable labour costs) or, respectively, train length-dependent (energy, wagon-specific rolling stock and terminal services).[325] As a second step, we compute the shares of the affected cost items as a proportion of total costs.

The estimates we use from the database are for the time frame 2018 – 2020, of which more than 60% of the data is for 2019. We take roughly 25% of our input data from the stakeholder consultation and 75% from publicly available sources.[326]

Following some adjustments to the data,[327] we compute the total variable cost share by each dimension. We then apply this variable cost share to the average costs per tkm to calculate the breakdown of the absolute costs.[328] Finally, for a given increase in travel distance or train length we scale up the variable share of costs proportionately.[329] As a

[325] Intuitively, increasing distance and length will result in the train utilising more energy (fuel and electricity). Particularly for an increase in distance, staff costs increase to cover the additional distance (either by shifts or by adding more members of train crew). Moreover, track access charges are also directly proportional to the distance travelled for a typical freight trip. Regarding train length, longer trains tend to incur additional rolling stock costs, that are wagon-specific only (additional wagons increase the average train length). We disregard the addition of a locomotive as this remains out of the scope of our analysis. Further, terminal service charges too tend to increase with longer trains (e.g., shunting, marshalling, etc.)).

[326] We observe that in some cases, there is missing input data for the simulation exercise. We therefore impute these estimates by calculating an average estimate for each variable across the different sources, years and freight categories. This assumption is also consistent with the methodology of presentation of costs, revenues and profitability as described in Section 4.2.1. Note that we also convert train length provided in meters to number of wagons by using publicly available data on the length of a standard train: See "Longer trains facts & Experiences in Europe": https://www.cer.be/sites/default/files/publication/200921_Longer%20Trains_Facts%20and%20Experiences%20in%20Europe_5thEd.pdf.

[327] See Annex 23.

[328] We follow a less conservative mapping here by matching average total cost per tkm to the average variable cost shares with respect to distance and length, by grouping the following dimensions: country, market participant, train type and national/international scope. We do this to ensure consistency with the methodology above, in line with the presentation of costs, revenues and profits.

[329] While it is easy to see the extent to which traction costs increase linearly with respect to distance, it is less clear in terms of magnitude to see, the linear increase in traction costs for an additional wagon. The "work" exerted by the train in this case is directly proportional to the mass. Relating locomotives in terms of

result, average costs per tkm decrease for the "new" travel distance or train length (which includes the incremental length/distance).[330]

Table 17 below shows the proportion of average variable costs that vary with distance and/or length for each country. Note that the variable cost shares shown below pertain to the average distance travelled and train length for each country.

Table 17: Average variable cost shares by country

Country	Traction share	Wagon rolling stock share	Variable labour cost share	TAC share	Terminal services share
Czech Republic	10.46%	8.58%	20.36%	7.95%	N/A
France	7.00%	12.80%	18.46%	8.00%	N/A
Germany	10.02%	9.87%	12.42%	11.51%	24.57%
Lithuania	15.23%	6.77%	8.34%	50.79%	2.50%
Netherlands	19.99%	16.14%	4.73%	23.28%	N/A
Poland	18.39%	7.89%	10.60%	18.81%	2.09%
Romania	18.65%	5.18%	26.07%	21.00%	N/A
Slovakia	12.12%	13.67%	14.76%	7.50%	7.00%
Spain	16.63%	5.15%	17.31%	2.57%	N/A

Source: The Consortium based on publicly available sources and stakeholder consultation.

Please see Annex 23 for more details on the variable cost shares across the different countries.

Contrary to costs, revenues do not react to distance or train length variation through an adjustment to their variable part. Revenues may even not be split into variable and fixed parts. They are largely driven by demand and competition. Therefore, we use alternative methods to approximate revenues as outlined below.

The response of revenues to changes in distance and train length depends on the competitive situation within the rail freight sector and with its competing modes. The level of competition may depend on national/international routes, train types or certain freight categories. Consider train types for instance. *Intermodal* and, to a lesser extent, *single-wagon* transport competes with trucks delivering cargo door-to-door (inter-mode), whereas block trains face little competitive pressure from road. Rather, competition mainly occurs within the rail segment (intra-modally). Block trains also have a

wagons, along with an added wagon provides a new weight for the total train. Difference between the previous ("old") and the current ("new") weight as a proportion of the "old" or previous train weight is very small, ~ 4%. This implies that traction costs may not increase exactly proportionately, but very close to it, at around 96% JASPERS, 2017; Lupi et. al (2019).

[330] Note that lack of input data such as costs per tkm that considers a correlation across different dimensions poses a problem for the simulation of costs and revenues. See section 4.2.1. Moreover, in the simulation we consider only variable cost items related to a specific train, and not fixed costs of making the infrastructure available. For certain train types, particularly single-wagon transport, the fixed costs are very high. Typically, incumbency advantages pertaining to increased economies of scale and infrastructural capabilities influence the costs and revenues in this respect. The simulation does not account for the effect of a change in train distance or train length on such costs.

lower price elasticity than intermodal and single-wagon modes.[331] Based on these observations, we model revenue changes resulting from an increase in transport distance or train length as follows.

In the block train segment, we assume that revenues largely follow costs and include a mark-up, the magnitude of which depends on the level of intra-mode competition. Consider that road transport exercises little to no competitive pressure upon *block trains* (second VDV interview). By and large, competition takes place between RU. Consequently, the price level depends on the number of competing railway undertakings in a specific country or on a particular route.[332] In a competitive market, shippers often put block trains out for tender. RU, in turn, undercut each other in an attempt to optimise their asset utilisation and cover fixed costs. Therefore, revenues largely follow costs. Only small margins are possible. In less competitive market segments, on the other hand, the dominating RU are not substantially restrained by competing RU. Thus, they will be able to charge a higher margin.

To model intermodal transport, we use truck prices to approximate revenues that RU can realise on different distances. Shippers are likely only willing to use intermodal transport if the price associated with its entire transport chain does not exceed the price of road transport.[333] Thus, we approximate revenues in intermodal transport using truck prices.[334] While this analysis concerns only the rail leg, the revenues of an intermodal transport chain are shared between several market players. Therefore, in order to isolate the share of revenues that can be allocated to the rail leg, we subtract from the truck prices all cost items related to first and last mile, transshipment and other non-rail parts of the transport chain.[335]

It is instructive to explicitly list the assumptions necessary to justify approximating intermodal transport revenues with truck prices. First, guided by the evidence that road imposes major competitive constraints upon intermodal transport, we assume that the full intermodal transport operation always equals the price of road transport. RU cannot charge more than their road competitors. Likewise, RU do not undercut road competitors due to their relatively high costs.[336] Second, we consider only 40’ containers and assume that they contain 18 or 20 tonnes of cargo. Third, we assume an 11% mark-up on all ancillary activities, i.e. first and last mile services, transshipment and other non-rail services.

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[331] Refer to Section 4.7 for a review of the degree of competition between train types and other modes.

[332] Recall from Table 3 in Section 1 that the number of RU varies substantially across Member States. Note however, that, even within a country, the level of competition differs depending on the considered region or corridor. It is therefore difficult to derive general statements for entire Member States.

[333] According to, inter alia, interviews with FerCargo, AEFP and VDV. Besides the pure transport costs, shippers also consider other factors, depending on their preferences and the cargo shipped. These include i) transport time, where road transport usually has an advantage over intermodal transport, ii) reliability (likelihood and magnitude of delays), where road transport usually outperforms rail, and iii) environmental impact: shippers and end-customers increasingly value the environmental impact of the chosen transport mode, but the price of intermodal transport still needs to be reasonably close to the price of road transport. Further evidence about shippers’ preferences from national case studies points to the importance of cost considerations in countries where rail freight is perceived to be more expensive than road, see “Freight on road: why EU shippers prefer truck to train”: https://www.europarl.europa.eu/RegData/etudes/STUD/2015/540338/IPOL_STU(2015)540338_EN.pdf. We also observe from the same study that there was a strong bias against the use of rail and intermodal services, when it came to shipper perceptions of rail versus road-only transportation services (Patterson et al.2008).

[334] We collected truck prices from upply, a data provider of truck prices on various European routes (https://www.upply.com/en-gb/). We use tautliners carrying 18 or 20 tonnes of general cargo for reference spot prices. To obtain a general relation between distance and unit prices (in terms of tkm), we fitted the data by numerically optimising the parameters of the function $Cost = a_g + b * distance^{-c}$, where the subscript g indicates different intercepts for domestic and international routes.

[335] We subtract costs of transshipment, first and last mile services, and overhead costs using estimates provided in PWC & KombiConsult (2022), including a mark-up of 11%. The mark-up is informed by the range of profitability described in 4.6.2.1. We consider transshipment of a 40’ container by efficient gantry cranes, and by less efficient hydraulic material handling cranes. For more details on the costs of transshipment technologies, please refer to PWC & KombiConsult (2022).

[336] This may not always hold true. For long-distance transports on the Ten-T corridors, for instance, combined transport may be substantially cheaper than road transport.

Regarding the train length dimension, intermodal transport organisers sell their slots by container.[337] Thus, we assume RUrevenues per container (and consequently, revenues per tkm[338]) are also constant – irrespective of the number of wagons.[339]

We cannot conduct a similar analysis for single-wagon transport, because it is not as substitutable with road as intermodal transport is. On an operational level, loading and unloading containers may differ from handling 70-tonne wagons. Even more importantly, forwarding freight via single-wagon transport is a long-term decision for the shipper.[340] It requires a substantial investment before the first shipment can be performed, e.g. in a private siding. Road transport still exercises competitive pressure, but it is unclear to which degree and how exactly it is affected by the distance and train length. For this reason, adding a blanket margin on costs to approximate revenues, as we assume is reasonable for block trains, is unlikely to be an adequate solution for single-wagon. Furthermore, the number of railway undertakings competing for single-wagon transport is substantially lower than for block trains. Therefore, we do not assess the effect of transport distance and train length on single-wagon revenues.

In the figures below, we will present the results of the simulation exercise first with respect to travel distance, and subsequently with respect to train length for each dimension. Please see 4.2.1 for the methodological details for the calibration of the cost functions.

4.3.2 Overall

Figure 30 provides results of the simulation of average costs per tkm change due to increases in distance travelled and train length for all countries where such that data is available ("overall sample").

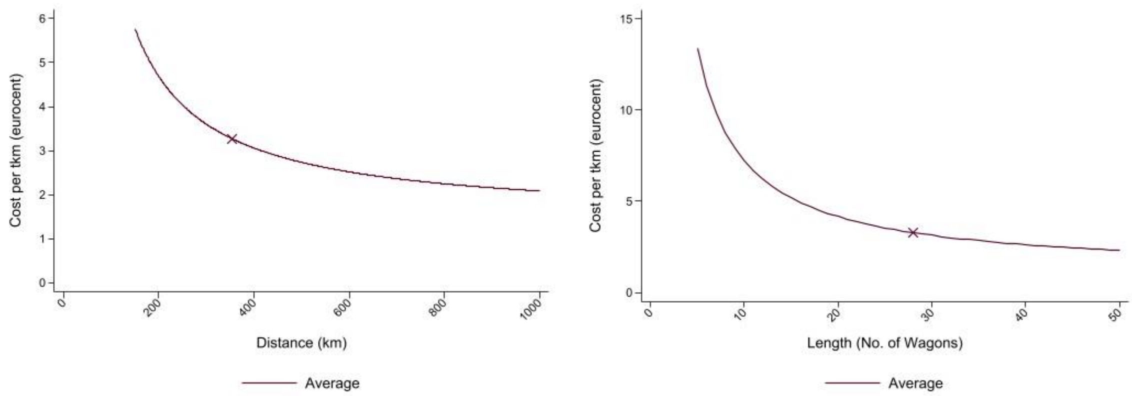
[337] Interviews with LTG Cargo, FerCargo and VDV. See also *CMA CGM Inland and Intermodal Services in Europe*: the process of booking shipments starts with "*book a container*", https://www.cma-cgm.com/products-services/multimodal-solutions/europe.

[338] Constant revenues per container also imply constant revenues per tkm with respect to train length. Consider doubling the number of containers. If the second set of containers weighs on average the same as the first set, the total net weight is doubled. Holding fixed the transport distance implies that the performed tkm are doubled as well. The assumption of constant revenues per container entails also a doubling of revenues. Thus, increasing the number of containers increases revenues by the same amount (in percentage terms). Still, revenues per tkm are not constant with respect to transport distance, as outlined above and illustrated in Section 4.3.3.

[339] This holds true at least for the revenues of intermodal transport organisers, while the revenues a RU obtains from the intermodal organiser might be different. However, for the assessment of the competitiveness of intermodal transport (as a system consisting of the intermodal organiser and the RU) compared to road transport, this assumption is still useful, because the analysis is informative on how train length affects the competitiveness of intermodal transport. However, the model is not informative about how intermodal organisers and RU share the revenues.

[340] Refer to Section 2.5 for a discussion on the investment costs of private sidings.

Figure 30: Overall country-level costs per tkm by distance and length



Source: The Consortium based on publicly available sources and stakeholder consultation. Note that the crosses represent the average distance travelled (left), train length (right) and the average cost per tkm, respectively. This is applicable for all figures in this section.

We make the following observations regarding costs with changes in distance travelled and train length for the overall sample:

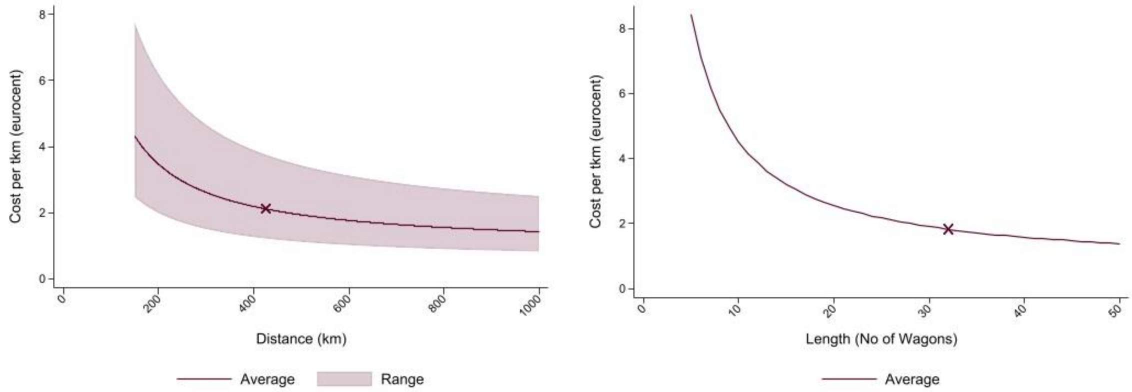
- The distance-dependent cost function above (to the left) represents how average costs per tkm change as a result of the affected variable cost shares, with changes in distance travelled for the following countries: the Czech Republic, Germany, Lithuania, the Netherlands, Poland, Romania, Slovakia and Spain.
- The length-dependent cost function above (to the right) represents how average costs per tkm change as a result of the affected variable cost shares, with changes in length for the following countries: Germany, Lithuania, Poland, and Slovakia.
- On average, the cost per tkm for these countries is around 3 cent/tkm. Accordingly, the average distance-dependent variable cost share is around 44% and the average length-dependent variable cost share is 33%.
- With an increase of 100 km for an average travel distance (of 354 km), the costs per tkm decrease by around 12%.
- With an addition of 1 wagon to the average train length (of 28 wagons), the costs per tkm decrease by around 2%. Note that cost-efficiency gains are higher when wagons are added to shorter trains, i.e., between 10 – 20 wagons and subsequently, efficiency gains are lesser when wagons are added to longer trains.

Please see Annex 23.3 for graphs for the above-mentioned countries.

4.3.3 Train types

Figure 31 provides results of the simulation of average costs for block trains with changes in distance travelled and train length.

Figure 31: Block train costs per tkm by distance and length



Source: The Consortium based on publicly available sources and stakeholder consultation. Note: The shaded region shows the range of the cost functions calibrated for the available data. The maximum cost function considers the maximum distance or maximum length and maximum variable cost share. Similarly, the minimum cost function considers the minimum distance or minimum length and the minimum variable cost share.

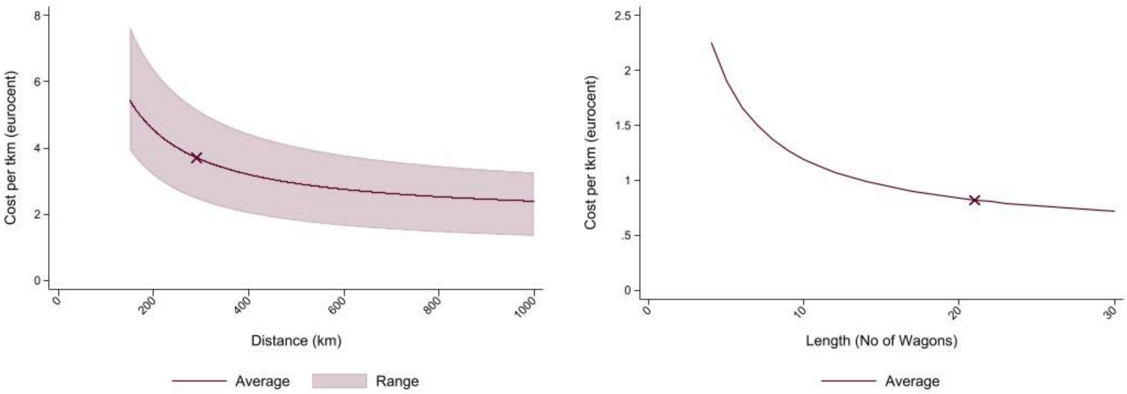
We make the following observations regarding block train costs for changes in distance travelled and train length:

- Block trains complete an average distance of between 377 km and 449 km, and have between 30 – 34 wagons.[341]
- The distance-dependent variable cost share is between 39% and 46% for block trains, and length-dependent variable cost share is around 32%, in relation to total costs.
- An additional 100 km could decrease average costs per tkm for block trains by about 10% – 13%, and an additional wagon could decrease average costs per tkm for block trains by about 2%.

As discussed in Section 4.3, revenues are assumed to follow costs, and the mark-up depends on the level of intra-modal competition.

Figure 32 provides results of the simulation of average costs for single-wagon transport, with changes in distance travelled and train length.

Figure 32: Single-wagon costs per tkm by distance and length



Source: The Consortium based on publicly available sources and stakeholder consultation.

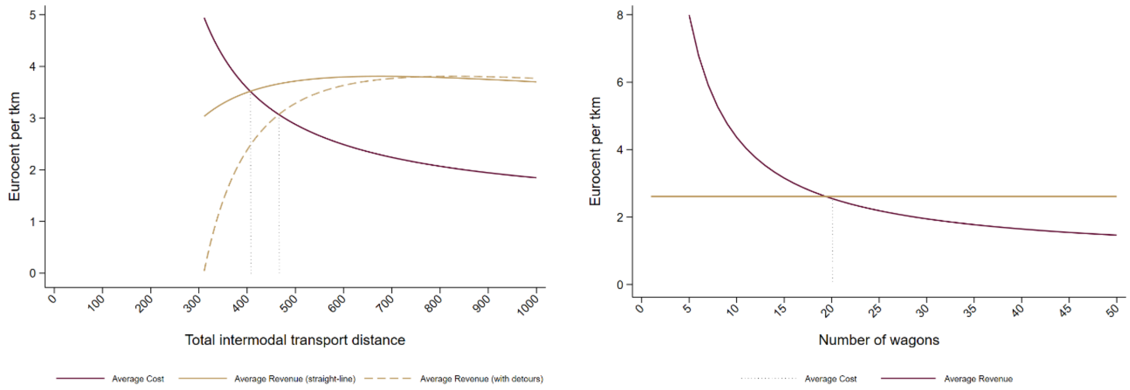
We make the following observations regarding single-wagon transport costs for changes in distance travelled and train length:

- Single-wagon transports complete an average distance of between 200 km and 450 km, and have between 5 – 30 wagons.
- The distance-dependent variable cost share is between 40% and 55% for single-wagon transport and the length-dependent variable cost share is around 25%, in relation to total costs.
- An additional 100 km decrease average costs per tkm for single-wagon transport by 10% to 19%, and an additional wagon decreases average costs per tkm for single-wagon transport by 12%.

Figure 33 provides results of the simulation of average costs and revenues for inter-modal transport with changes in distance travelled and train length.

[341] Number of wagons converted to the nearest unit's place, due to conversion of meters to wagons.

Figure 33: Intermodal transport costs and revenues per tkm by distance and length



Source: The Consortium based on publicly available sources and stakeholder consultation. The left panel displays two lines to approximate revenues with truck prices. The solid line emerges from the assumption of a straight-line connection of an intermodal transport chain, i.e. the rail leg as well as first and last mile are on the same optimal path as is a road-only transport. The dashed line, on the other hand, reflects an assumption that first and last mile are "detours" to access the rail infrastructure. For both lines, the adjusted price for road transport excludes costs of and an assumed 11%-mark-up on transshipment, first/last mile and overhead costs. We assume an average of the transshipment technologies gantry crane and hydraulic material handling crane. The x-axis represents total transport distance, i.e. it includes two road legs of 75km each. Revenues on the right panel constitute an average of the intermodal transport revenues, as reported in Section 4.2.3.

We make the following observations regarding intermodal transport costs for changes in distance travelled and train length:

- Intermodal transports on average cover distances between 278 km – 688 km, and in terms of train length, pull between 19 – 32 wagons.
- The distance-dependent variable cost shares are between 44% – 48% and the length-dependent variable cost share is around 33% of total costs.
- An additional 100 km decreases average costs per tkm for intermodal transport by 7% to 15% and an additional wagon decreases average costs per tkm for intermodal transport by 3%.

Concerning the interplay between costs and revenues, costs exceed revenues for intermodal transport over short distances. The pure intermodal shuttle service is efficient, but the costs that are fixed in terms of distance, mainly transshipment as well as first and last mile, are too high for a short-distance transport to be profitable. On longer distances though, these fixed costs are allocated over a larger distance and are proportionally smaller. Therefore, revenues tend to exceed costs. The average break-even is between 407-466km.[342] This finding supports the conclusions of the detailed discussion of the minimum distance to achieve profitability in Section 4.4.

Regarding train length, the revenues reflect the range of revenues from the model basis (see Section 4.2.3). The discussed assumption of constant revenues per container explains its unresponsiveness to changes in train length. The intersection of revenues and costs suggests that intermodal transport starts becoming profitable for the RU at 20 wagons on average.[343]

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[342] This distance range refers to the total transport distance of an intermodal chain, including in particular first and last mile. The assumption outlined in Section 4.3.1 moderate the break-even. Indeed, a higher mark-up on complementary services or less efficient transshipment technologies would increase the break-even distance.

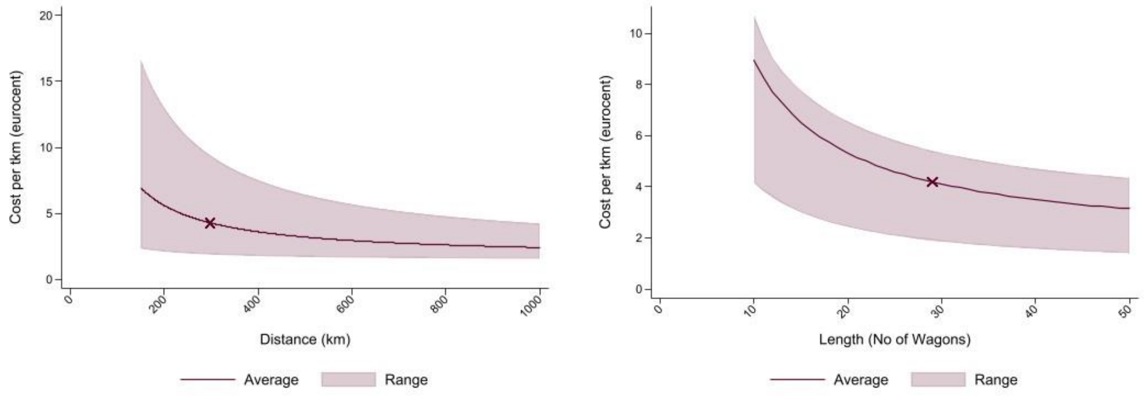
[343] Please note that both the cost curve and the constant revenues reflect averages of the available data. Depending on circumstances like the country in question, transshipment technology or willingness to pay, the intersect might shift in either direction. Furthermore, recall that the assumption of constant revenues per container is a simplification motivated by industry practice, but may not always be entirely accurate.

4.3.4 Market participant types

Generally, incumbents and non-incumbents tend to have different cost structures. For instance, incumbents face higher labour costs and overhead costs than entrants. This may lead to different results in the analysis.

Figure 34 provides results of the simulation of average costs for incumbents with changes in distance travelled and train length.

Figure 34: Incumbent costs per tkm by distance and length



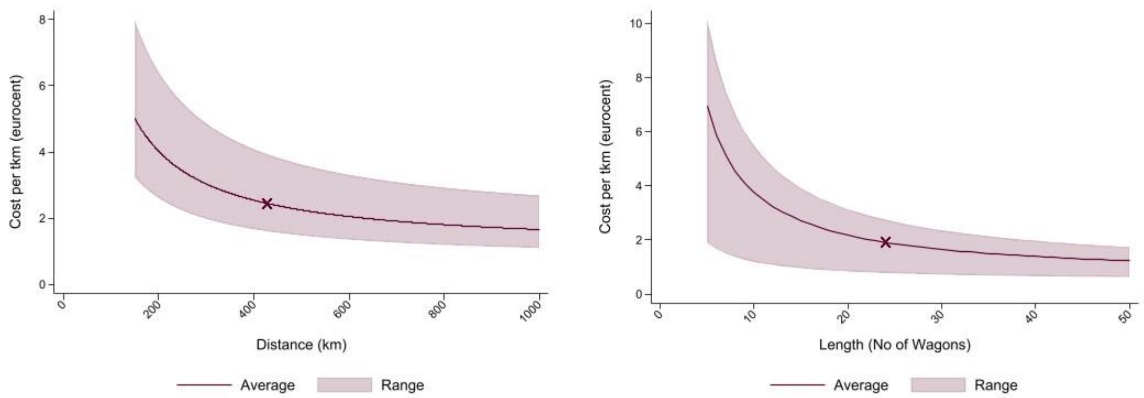
Source: The Consortium based on publicly available sources and stakeholder consultation.

We make the following observations regarding incumbent costs for changes in distance travelled and train length:

- Incumbents on average cover distances between 187 km – 467 km, and in terms of train length, have between 19 – 53 wagons.
- The distance-dependent variable cost shares are between 29% – 79% and the length-dependent variable cost share is around 26% – 43% of total costs.
- An additional 100 km could decrease average costs per tkm for incumbents by 5% to 23%, and an additional wagon could decrease average costs per tkm for incumbents by 1% to 3%.

Figure 35 provides the results of how average costs change for non-incumbents with changes in distance travelled and train length.

Figure 35: Non-Incumbent costs per tkm by distance and length



Source: The Consortium based on publicly available sources and stakeholder consultation.

We make the following observations regarding non-incumbent costs for changes in distance travelled and train length:

- Non-incumbents on average cover distances between 319 km – 688 km, and in terms of train length, have between 5 – 30 wagons.

- The distance-dependent variable cost shares are between 38% – 46% and the length-dependent variable cost share is around 25% – 33%.
- An additional 100 km could decrease average costs per tkm for non-incumbents by 7% to 15%, and an additional wagon could decrease average costs per tkm for non-incumbents by 2% to 12%.

As noted previously within the limitations, we note that some of the "incumbency" effects may be significantly driven by the fixed costs incurred, to account for economies of scale and other infrastructural benefits. We may therefore not be able to observe these effects as we only consider variable cost shares. Moreover, there might be correlation between train types and market participant types.

CONCLUSIONS:

Generally, results from the simulation of costs and revenues of RU with respect to changes in travel distance and train length suggests:

- With an increase of 100 km for an average travel distance (of 354 km), the costs per tkm decrease by around 12%.
- With the addition of one wagon to the average train length (of 28 wagons), the costs per tkm decrease by around 2%.
- Single-wagon operations complete an average distance of 200 – 450 km, and pull between 5-30 wagons. While their distance-dependent variable cost shares lie between 40% - 55%, their length-dependent variable cost share is around 25%. With an increase of 100 km, average costs per tkm decrease by about 10%-19%. Similarly, an additional wagon decreases average costs per tkm by 12%.
- Revenues follow costs for block trains in competitive markets. For intermodal transport, our model indicates average break-even points between 407-466 km and 20 wagons.

4.4 Minimum distance for break-even and competitiveness

The minimum distance, from which rail transport starts becoming profitable and/or competitive, is a specific topic that has been studied in various settings before. We use the term *minimal competitive distance* to assess the distance at which rail freight or intermodal transport becomes economically advantageous to road transport. A similar concept is the *break-even distance* which describes the distance above which rail freight becomes profitable, i.e. revenues exceed costs.[344]

Generally speaking, rail becomes more profitable and competitive if the length of the route increases. The main competition comes from road, which has lower fixed costs and tends to be cheaper on short routes. Railway undertakings, on the other hand, have high fixed costs, but relatively small variable costs, thus improving their competitiveness over longer distances.

We assess the issue of minimum distance for break-even and competitiveness from four angles: First, a review of literature; second, direct replies from the stakeholder consultation; third, information gathered in stakeholder interviews; and fourth by using data of actual train services provided by national infrastructure managers.[345] To preview our results, the sources point to a large range of "minimum distances", suggesting that there is no universally valid value. Rather, the critical distance seems to depend on a variety of circumstances, which are discussed in the remainder of this section.

4.4.1 Evidence from the literature

The available literature mostly focuses on the minimal competitive distance, i.e. the distance above which rail freight or intermodal transport is more competitive than road transport. More specifically, competitiveness is often assumed when the costs associated with providing rail freight services are equal or lower than the costs related to

[344] In the literature, both terms are sometimes used interchangeably or in slightly different definitions, so caution is advised when comparing results from different sources.
[345] Refer to Section 4.3 for a range of break-even distances for intermodal transport based on the cost-revenue framework of this study.

freight road transport. In case of intermodal transport, also the non-rail costs (especially transshipment, first and last mile) have to be considered.

Table 18 presents an overview of different estimates of the minimum competitive distances for rail freight found in the literature.

Table 18: Overview of the minimum competitve distance for freight trains

Authors	Year	Segment	Minimum distance	Relevant factors	Remarks
Van Klink and Van den Berge	1998	Intermodal transport	500 km	Infrastructure, Transshipment costs, Volume	Door-to-door distance
UIRR	2000	Single-wagon	450 km	Track access charges	International transport only
Harris and McIntosh	2003	Rail freight	160 km	Infrastructure, Freight category, Congestion levels	
Punakivi and Hinnka	2006	Rail freight	-	Freight category	
Janic M.	2008	Rail freight and Intermodal transport	700-1000 km	Train length	Door-to-dor distance
Tsamboulas	2008	Intermodal transport	400 km	-	Door-to-dor distance
Department for Transport (Dft)	2010	Rail freight	-	Infrastructure, Volume, Congestion levels	
ORR	2012	Rail freight	80-320 km	Infrastucture, Freight category, Volume	British market
Jackson et al.	2013	Rail freight	200 km	Last mile services	Terminal-to-terminal services only
Wisnicki and Dyrda	2015	Rail freight	500 km	Internalisation of external costs	Break-even distance
Directorate General for Internal Policies	2015	Rail freight	200-300 km	Literature	
Zgonc, Tekavcic and Jaksic	2019	Intermodal transport	60-478 km 104-1143 km	Last mile services, Route, Location	First or last mile only (door-to-terminal) First and last mile (door-to-door)
PWC and KombiConsult	2022	Intermodal transport	>600km	Transshipment technology, loading unit	Door-to-door distance

Source: The Consortium based on literature review.

Evidently, the literature does not provide a universally valid minimum competitive distance in the rail freight market. Indeed, Woodburn (2017) concludes that there is no academic consensus regarding the minimum competitive distance of rail freight transport. Instead, the literature indicates that the minimum competitive distance depends on different factors, for example the freight category, train type or available infrastructure. The following paragraphs present suggested minimum competitive distances from the literature and the factors influencing them depending on the studied train type[346]: intermodal, single-wagon, and overall rail freight transport.

When it comes to intermodal rail freight operations, academic papers find various minimum competitive distance and factors influencing its value. Van Klink and Van den Berge (1998) and Zgonc, Tekavcic and Jaksic (2019)[347] assume that door-to-door intermodal freight can be competitive vis-à-vis road only if the costs of the entire intermodal transport chain are equal to the costs for road transport. According to the former, this occurs from a distance of 500 km while the latter provides two ranges of distances (60-478 km or 104-1143 km) depending on whether both a first and last mile road leg are needed or only one of the two. As reported by Van Klink and Van den Berge (1998), the major factors influencing the minimum competitive distance are the availability of a dedicated infrastructure and the efficiency of transshipment. Generally, intermodal operations can equalise the costs of road transport when carrying large volumes over large distances. Zgonc, Tekavcic and Jaksic (2019) state that minimum competitive distances vary depending on the specific route, railway undertaking, and location. Finally, Tsamboulas (2008) reports that the minimum competitive distance that is commonly regarded as allowing intermodal operations to become competitive is above 400 km. PWC and KombiConsult (2022) assess that intermodal transport is costlier than road transport even at 600km.

Minimum competitive distances for single-wagon operations have been studied to a lesser extent in the literature. An early study by UIRR (2000) considers the minimum competitive distance between road and rail to be at around 450 km for single-wagon loads in international traffic, although the authors warn that this number could be higher depending on the level of track access charges.

Most publications investigate the minimum competitive distance for the overall sector of rail freight transport. Although the minimum competitive distance differs from study to study, the literature seems to agree on the major factors influencing it, namely the infrastructure, the type of freight and its volume. In the case of the infrastructure, for instance, shippers might decide against using rail transport due to the lack of terminals, congestion of lines, train derailments, and the high level of track access charges, hence increasing minimum competitive distance. On the other hand, the transport of large volumes of specific goods, such as chemical products or bulk cargo, reduces the distance needed for rail freight to be competitive against road.

Among those studies, Harris and McIntosh (2003) highlight how longer distances entail a competitive advantage for rail freight vis-à-vis road but that at more moderate distances – around 160 km - rail cost and quality are compatible with road transport. Relevant elements influencing the distance are infrastructure availability, type of freight, and congestion levels. A case study from Scotland (DfT, 2010) corroborates the importance of infrastructure in offering a timely service to interested shippers, stressing how delays in the service and lack of customer focus can increase minimum distance. Results from the Freight Costumer Survey (ORR, 2012)[348] suggest that rail becomes competitive at a range of 80-320 km, indicating that rail freight can in principle be

[346] The type of train can influence the minimum competitive distance between rail and road given cost differences among trains. For example, combined transport and single-wagon operations have fixed transshipment costs (e.g., marshalling/shunting), while block trains do not incur those costs. Holding other factors fixed, block trains would therefore achieve profitability at a lower distance than the other train types.
[347] Zgonc, Tekavcic and Jaksic (2019) use a Monte Carlo simulation approach to assess the minimum competitive point of rail transport considering road transport data.
[348] The Freight Costumer Survey is a report in which existing and potential rail freight customers are surveyed on rail market in the United Kingdom.

competitive on shorter routes depending on the type and volume of goods transported (especially bulk goods) and on the infrastructure availability.

The importance of freight type in determining the minimum competitive distance and modal choice is also stressed in the reports from the European Parliament (Directorate General for Internal Policies, 2015) and Punakivi and Hinnka (2006). The former study also provides the minimum competitive distance often referred to in the literature – 200-300 km. Minimum competitive distances can be reduced depending on the freight category as some goods need to be transported by trains (e.g., chemical products). Additionally, trains that transport high volumes of goods tend to have lower minimum profitable distances, keeping all other factors constant.

Further studies focus on other factors influencing the minimum competitive distance such as the provision of last mile road leg services[349] or the type and length of the train[350]. PWC and KombiConsult (2022) emphasise the importance of which transshipment technologies and loading units are employed for the competitiveness of intermodal transport. Additionally, Wisnicki and Dyrda (2015) report that, in Europe, rail freight transport can be competitive at distances of above 500 km. The same applies to intermodal rail-road connections. However, currently, the calculation of the price for transport services considers only internal transport costs. If, however, road transport services also had to cover their external costs, their competitive position would deteriorate significantly compared to rail freight and smaller minimum competitive distances for rail and intermodal solutions could be achieved. More generally, there exists a direct link between truck transport costs and rail minimum competitive distance insofar as rail and road are close substitutes.

To conclude, publicly available literature mainly focuses on the analysis of the competitiveness of rail freight or intermodal transport compared to road transport by investigating the factors influencing rail costs vis-à-vis road costs.[351] Although the academic literature reaches different ranges in terms of minimum competitive distance, studies focusing on the rail freight sector seem to agree that infrastructure, type of freight, and volume are the most important elements influencing costs and, therefore, modal choice.

4.4.2 Evidence from the stakeholder consultation

In the context of the stakeholder consultation, the Consortium asked RU and other stakeholders directly for their assessment of the break-even distance for rail freight, i.e. the distance above which revenues for a given service cover the costs. Similar to the results of the literature, the responses from the stakeholder consultation provide a wide range of break-even distances. Table 19 summarises the replies.

Table 19: Break-even distances from stakeholder consultation

Country	Stakeholder	Assessment of break-even distance			
		Entire sector	Block train	Single-wagon	Intermodal transport (terminal-to-terminal)
(conf.)	Railway Undertaking	-	300 km	500 km	600 km

[349] Jackson et al. (2013) find that the minimum competitive distance for a potential modal shift from road to rail is around 200 km (only terminal-to-terminal services). Whenever last mile services are required, the relevant distance might be higher.

[350] Janic M. (2008) compares conventional freight trains and long intermodal freight trains, both operating on a given European rail freight corridor. As freight trains can take advantage of economies of scale, longer trains have lower average costs. As a consequence, the minimum competitive distance decreases for longer trains compared to shorter ones. The author estimates that the minimum competitive distance could decrease from 1000 km to 700 km when switching to long trains that transport a higher volume by using more wagons.

[351] As outlined in Section 4.2.1, road revenues can proxy rail revenues in cases when road and rail compete fiercely for the same shipper, suggesting that the minimum competitive distance can be representative of the minimum profitable distance for rail freight as the two modes differ only in terms of their costs.

(conf.)	Railway Undertaking	-	500 km		500 km
Poland	LOTOS	-	300 km	200 km	300 km
(conf.)	Railway Undertaking	-	100 km	200 km	150 km
(conf.)	Railway Undertaking	-	100 km	300 km	100 km
(conf.)	Market regulator	100 km	-	-	-
Spain	Market Regulator	285 km*	-	-	-
Sweden	Market Regulator	300	-	-	350

*Source: The Consortium based on stakeholder consultation. *The Spanish regulator CNMC stated that the break-even distance is 285 km, provided that the railway undertaking has enough cargo to fill a block train of around 600 net tonnes.*

There is substantial heterogeneity in levels, but the suggested distances fall into the range suggested by the literature on competitive distance (see Table 18). All responses indicate that the minimum distance for intermodal transport is equal or larger than for block trains. Likewise, most stakeholders indicated higher break-even distances for single-wagon transport that for block trains.[352]

Beyond the presented raw figures, some stakeholders elaborated further on other factors that affect the minimum distance and profitability in general. An anonymous railway undertaking pointed out that increasing the train length limit could decrease unit costs and thus also the minimum distance required to achieve break-even. Furthermore, the availability of intermodal terminals plays a vital role for intermodal transport in particular (see also Section 2.3).

We gathered further information from several stakeholder interviews. The *frequency of transport services* seems to be an important factor. A representative of the Spanish association *Asociación de Empresas* Ferroviarias highlighted the Martorell-Barcelona route, where rail freight operations are profitable on a very short route (about 35 kilometres, terminal-to-terminal distance), with the high frequency of shuttles being the main enabling factor. The statement suggests that the minimum profitable distance cannot be treated independently from service frequency.

The *Opérateurs Ferroviaires de Proximité* (OFP), an association that represents operators focussing on short-distance routes in France, stressed that short routes of 100 km or even less can, in principle, be profitable without subsidies. However, this requires a lean and agile organisation. A representative of *FerCargo*, an association of non-incumbents in Italy, considers that rail freight transport of high value goods (e.g. chemicals) might become profitable at around 150 km. The distance would be higher for intermodal transport or low value goods.

4.4.3 Short-distance operators

In some MS, there are specialised short-distance rail freight operators which often operate profitably.[353] At least in some cases, they are subcontracted by large RU to provide partial services of a multi-leg transport chain (for example in Germany, see Bundesnetzagentur 2022). Marshalling and shunting operations as well as feeder and distribution legs are typical short-distance rail services. Single-wagon systems can benefit from a dense network of short-distance operators offering such services.[354] Regional, short-distance rail services can differ from long-distance rail freight services not only in terms of distance, but also in their technical implementation. The main leg of a single-wagon

[352] Only the RU Lotos indicated otherwise, see Table 19.
[353] Please note that there is no unified definition of short-distance operators. Annex 26 discusses the traditional dense network of regional RU in Germany and the emerging market structure of regionally active *OFP*s in France.
[354] For a discussion about the state and future of single-wagon transport, please refer to the dedicated box discussing in Section 4.2.3.

transport chain typically requires a different set of resources than the first- and last-mile (e.g. staff and locomotives, see e.g. Bundesnetzagentur, pp.32-33). For example, marshalling and shunting operations are usually conducted with light-weight diesel locomotives whereas the mainline train requires a heavy locomotive, usually equipped with an electric drive. Other activities of short-distance operators include, but are not limited to, hauling block trains on short distances, providing and maintaining regional infrastructure and repairing rolling stock.

The Consortium assesses that the supplier structure of short-distance operators, and thus the availability of and access to short-distance services, varies substantially between countries. The total number of operating RU in a country might be a first indication of availability and access to short-distance services. Table 3 in Section 1.3 illustrates a high heterogeneity in the incumbents' market shares (in total rail freight, i.e. including long-distance) and the number of RU across MS. As per this analysis, we observe that the number of RU per MS is between 1 and 291. Similarly, the market share of the incumbent virtually ranges from 0 to 100%. Poland, for instance, is home to 85 RU and the incumbent's market share is 50% (IRG 2021). Such a high number of RU, paired with a relatively low market share of the incumbent, likely implies a reasonably high level of competition and entails a diverse structure of suppliers. While these statistics refer to the total rail freight sector and not specifically to local or regional complementary services, it seems plausible that countries with a large number of active freight RU also have a diversified structure of regional rail freight companies offering shunting/marshalling and local distribution services.[355]

Table 20 depicts the supplier structure of short- and long-distance services in selected European countries, based on extensive desk research.

Table 20: Supplier structure of short- and long-distance operators

Country	**Total Number of RU (2019)**	**Number of RU analysed (2022)**	**Number of short-distance operators**				**Number of long-distance operators**
			Total	Marshalling/ Shunting	Distribution/ Feeder	Single-Wagon	
Austria	38	26	17	10	7	8	25
Czechia	96	22	15	15	6	4	15
France	27	7	2	2	1	2	7
Germany	231	43	34	25	17	10	31
Italy	23	17	12	9	5	7	15
Lithuania	2	5	2	2	0	0	4
Netherlands	31	20	5	3	2	2	19
Romania	20	21	17	16	1	7	18
Poland	85	23	17	17	3	3	13
Slovakia	44	15	11	9	1	4	13
Spain	12	10	6	4	2	1	9
Sweden	11	6	3	2	1	2	5
Switzerland	25	7	3	2	2	2	6

[355] For instance, Germany has a large number of rail freight operators, whereas France used to be dominated by the domestic incumbent, SNCF, but took measures to improve the regional rail freight supplier structure. Both cases are treated in more detail in Annex 26.

Total	645	222	144	116	48	52	180

Source: The Consortium based on desk research. Column "Total Number of RU" applies to the year 2019 and is based on IRG-Rail (2021). The Consortium compiled the information in this Table by systematically classifying RU based on information from their websites. This approach only allows for an incomplete coverage of RU as not all rail freight operators advertise their services on a website and not all websites could be found via desk research. The scope of non-complete coverage can be approximated by relating the second column to the third. Interestingly, the number of websites the Consortium identified in Lithuania and Romania exceeds the number of RU as reported in IRG-Rail (2021) which refers to 2019. This suggest that new RU entered the market since 2019. Please also note that the classification based on the information available on the RU's websites is not exact. For instance, some logistics operators simply subcontract rail haulage to undertakings with a railway license. Others own and operate rolling stock. Both types of firms might state on their website that they offer rail services to their clients. Furthermore, the number of railway undertakings is only a crude proxy for the availability of short-distance services which also depends on factors like the capacity of the RU and the network density. Lastly, consider also that the ease of access to short-distance services likely varies within different regions of a MS. There might be MS with an overall satisfactory supply of short-distance services that might still have areas with no or too few regional providers.

Table 20 reveals substantial heterogeneity across countries.[356] For instance, Austria, Germany, the Czech Republic and Italy are characterised by a reasonably high number of RU that provide short-distance services. This is indicative of a dense network of regional suppliers that offer short-haul services as an input to long-distance operators. On the other hand, the number of short-distance operators in Sweden and Spain is fairly low which suggests a lack of short-distance services, at least in some parts of the countries. The results also vary with respect to the specific type of short-distance service.

CONCLUSIONS:

A universally valid minimum competitive or break-even distance does not exist. Rather, the minimum distance, from which rail operations become profitable or even competitive, depends on a number of factors. Most sources point to a minimum distance between 100 and 600 km, but distances outside this range are also quoted. High freight volumes and shuttle frequencies can potentially make even short distances profitable and competitive. Similarly, high-value cargo or goods that, by regulation, are required to be transported by rail can reduce this distance in some circumstances. Furthermore, efficient transshipment and last mile transport improve the competitiveness of intermodal transport, thus decreasing the minimum competitive distance. Lastly, the timeliness of the service can affect the minimum competitive distance. If the rail infrastructure is congested and timetables are not met, road transport is relatively more attractive and the minimum competitive distance increases.

There are specialised short-distance rail freight operators active in the market; their number and the types of services they offer differ across MS. Often, these short-distance operators are subcontractors of long-distance Ru and provide inputs to complex transport chains, such as shunting services or the regional distribution of single-wagon operations.

4.5 Simulation of cross-border effects

Cross-border rail transport is much more complex for rail than for road due to infrastructural differences, differences in operating and safety regulations and language barriers across Europe, that result from individualised national railway systems. This gives rise to technical interoperability issues as well as other broader labour-related challenges, which we will briefly cover in this Section.

Using publicly available data, supplemented with additional qualitative assumptions and research, as well as input from several stakeholders, we then estimated costs incurred by crossing borders.[357]

Firstly, we identify the different cross-border challenges between the national railway systems. We categorize them into (i) technical interoperability issues, (ii) labour-related

[356] Annex 26 reports on insights from market regulators that were gathered during the stakeholder consultation and echo the notable differences between MS.

[357] Note that we present results only for countries where we have received input and validation for our assumption through information gathered from the relevant stakeholders.

constraints and (iii) general administrative constraints. We discuss these issues below, and subsequently present the methodology underlying our cross-border cost extension.

Technical interoperability issues arise from:

- *Break-of-gauge* due to different track gauges, i.e., the distance between the two rails of the freight railway track. There are three types of gauges: (i) standard gauge, (ii) broad gauge and (iii) Iberian broad gauge. The standard gauge is about 1435 mm. Meanwhile, the majority of the broad-gauge networks found in Finland and the Baltic States (1520 – 1524 mm) and Spain and Portugal have the Iberian broad gauge (1668 mm).[358]
- *Differing traction currents* i.e. the tension or the voltage used in the electrified tracks across Europe. The main systems in use are 15 kV 16.7 Hz AC, applicable to Germany, Austria, Switzerland, Sweden and Norway; 25 kV 50 Hz AC in Northern France, CEEC, Portugal and in some parts of Belgium, Netherlands and Luxembourg; 3 kV DC in Italy, Russia, Poland, Spain and Belgium and finally 1.5 kV DC in Southern France and Netherlands.
- *Differing train protection systems* that include safety and signalling measures to ensure trains efficiently move and accidents are minimal.[359]

Broader labour-related cost considerations stem from changes in the wages of drivers between the MS, language barriers and the lack of a "single" rail language, international license requirements for drivers and other differences in training and certification requirements for drivers and other train staff.

Additionally, we have wait-time related costs at the border crossing points (BCPs) (that are often a by-product of the above challenges).

We then place the different BCPs, for which reliable data is available, in three categories: "easy" (Austria, Germany and Switzerland), "medium" (Spain and Portugal) and "hard" (Spain and France, and Lithuania-Poland) according to how similar they are in terms of the above infrastructural and other administrative aspects.[360] Passenger rail transport exhibits similar difficulties while crossing the borders.[361]

We then identify the cost items affected by the differing standards and in line with the solutions chosen to solve the interoperability issues at the BCPs:

- Break-of-gauge: The break-of-gauge issue is solved either by (i) change of axle or (ii) transshipment. Moreover, the AEFP advised that the use of wheelsets to adjust for different gauges increases rolling stock costs, along with the cost of changing axles in the case of (i) and the need for additional wagons for transshipment (ii). Depending on the method of solving the break-of gauge issue, we received input from stakeholders (LTG Cargo and AEFP) that the cost of transshipment may vary from EUR 30 -50 per wagon for Lithuania-Poland, and EUR 1,700 – 4,000 per train for Spain-France respectively.[362]
- Differing protection systems and traction currents: Increase in rolling stock costs owing to different protection systems and traction currents, which may require

[358] See EC Case Study: "Easing legal and administrative obstacles in EU border regions": https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/obstacle_border/5_rail_transport_austria-slovenia.pdf.
[359] See "European Train Control System": https://www.trackopedia.info/encyclopedia/infrastructure/european-train-control-system-etcs.
[360] Note that AEFP categorizes the *Linea Figueras Perpigna* (LFP) UIC Line at the Spain-France BCP as "medium" level of difficulty.
[361] See "Chronotrains EU": https://chronotrains-eu.vercel.app/.
[362] Information provided by AEFP and LTG Cargo.

multi-system locomotives, that are on average approximately 27% more expensive than the standard locomotives.[363] Separately, the Spanish association advised that the rolling stock costs increase by roughly 15% due to the Spain-Portugal border.[364]

- Labour cost considerations: We found that labour costs to increase by roughly 12.5% - 15% for the medium and hard categories respectively, i.e., for Spain-Portugal and Spain-France and Lithuania-Poland.[365] It is also important to acknowledge that some of the cost considerations, such as inconvenience and uncertainty, are difficult to quantify.
- Wait-time and associated labour costs: The Spanish association confirmed that this is roughly around 10 mins for the border-crossing between Spain and Portugal, and around 10 hours for Spain and France, depending on the technical solution adopted for the break-of-gauge.[366] Additionally, stakeholders suggested the break-of gauge issue at the Lithuania-Poland BCP (Šeštokai terminal or the Kaunas intermodal terminal) requires them to organise transshipment through "reachstackers" or "gantry cranes" which reload cargo on wagons that are compatible with either 1435 mm gauge (serving Poland) to 1520 mm gauge (serving Lithuania) or vice versa. This can take at least 5 hours.[367]

The modelling approach can be broken down the following key steps:

- We first consider sector average costs per tkm for Spain, Lithuania and Poland.[368]
- We next consider average travel distances using data from publicly available sources. Alongside this, we quantify average speed of freight trains in Europe, which is believed to be around 25 km/h.[369] The average time for a trip is then imputed from the respective distance and speed.
- We then consider average cost-item shares for rolling stock and variable labour costs by country as shown in Table 21 to compute the absolute costs for each affected category (both rolling stock costs and variable labour costs).[370]
- Subsequently, we compute the "new" time taken (including wait time at the border) and estimate the increase in variable labour costs attributable to the incremental time.
- The transshipment costs are also added in terms of costs per tkm by accounting for both the relevant number of wagons in each country and an average estimate of assumed tonnage of cargo, along with the average distance travelled.[371]

Finally, the difference between the affected absolute costs, as a sum of the affected (new) costs and the sum of the affected baseline average costs, and as a proportion of the baseline overall average cost per tkm for each country provides an estimate of the increase in costs due to the above mentioned cross-border effects.

Table 21 provides details on the affected cost categories as a result of cross-border effects:

[363] Interview with Fercargo. Also see: Railway Pro: https://www.railwaypro.com/wp/multi-system-locomotives-still-too-expensive-for-operators/ ; Obstacles to cross-border rail freight in the European Union: https://www.ncl.ac.uk/media/wwwnclacuk/newrail/files/NewRail_Final.pdf.

[364] Information from AEFP.

[365] AEFP advises there is an increase of 12.5% in labour costs for the LFP UIC line between at the Spain-France BCP.

[366] Note that the LFP UIC line between Spain-France takes 5 mins.

[367] Information from LTG Cargo.

[368] CNMC Annual Report, 2019; Lithuania Incumbent Annual Report 2019; UTK Regulator Report 2019.

[369] See https://www.eca.europa.eu/Lists/ECADocuments/SR16_08/SR_RAIL_FREIGHT_EN.pdf ; https://etrr.springeropen.com/articles/10.1186/s12544-020-00453-3 ; https://www.railfreight.com/intermodal/2020/09/09/when-average-speed-dips-below-40km-h-railways-should-be-free/

[370] We consider the average cost shares and average overall costs by country to calculate the absolute cost increases for rolling stock and labour.

[371] JASPERS, Eurostat; and other publicly available data as well as input from stakeholder consultation.

Table 21: Computation of cross-border cost increases

Border	France - Spain (axle change)	Spain - France (transshipment)	Spain - France (LFP UIC line)	Spain-Portugal	Lithuania-Poland
Country	Spain	Spain	Spain	Spain	Lithuania
Average Cost (Eurocent/tkm)	2.60[372]	2.60	2.60	2.60	2.55[373]
Average Distance*	407.72	407.72	407.72	407.72	293.09
Wait Time (hours)	10.00	10.00	0.08	0.17	5.00
Rolling Stock Costs (Increase)	*Included in Transshipment Costs*			15%	27.14%
Labour Costs (Increase)	15.00%	15.00%	12.50%	12.50%	15%
Transshipment (Eurocent per tkm)	1.56	0.66	0.33	N/A	0.31
Total Affected New Costs	2.80	1.90	1.29	1.03	1.04
Change in Costs (%)	73.22%	38.64%	15.03%	4.93%	20.20%
Average Cost due to Cross-border effects (Eurocent per tkm)	4.50	3.60	2.99	2.73	3.07

Source: The Consortium based on Eurostat, Company annual accounts and stakeholder consultation. Notes: Eurostat; Note that the distance is computed as total tkm/tonnes.

On a more qualitative basis, we can conclude that these costs may not considerably increase in case of the "easy" category, i.e., between Germany, Austria and Switzerland since the differences in terms of technical standards of the rail freight infrastructure are minimal and additionally, there are few differences in terms of languages, wage levels and other cost considerations in so far as labour is considered. Our findings suggest that the "medium" level of difficulty in crossing the border between Spain and Portugal could increase average total costs per tkm by about 5%, and for the "difficult" BCPs, between Spain and France by about 38% - 73% depending on whether the axle change or transshipment is chosen to solve the break-of-gauge issue (with the former being costlier), and for Lithuania-Poland by about 20%.

Please see Annex 24 for detailed explanation of the data and relevant data sources.

CONCLUSIONS:

Generally, the issues faced while crossing borders between MS arise mainly due to (i) technical interoperability, (ii) labour-cost considerations and (ii) other general administrative constraints. Consequently, the cost categories affected due to technical interoperability include rolling stock costs and transshipment costs and more broadly variable labour costs, such as wait-time induced labour costs. The extent to which costs increase depend on the technical solutions adopted to solve interoperability issues and also the level of variation in other socio-economic factors on either side of the border, while considering labour-related costs. The cost increase

[372] CNMC Annual Report (2019).
[373] LTG Cargo Annual Report (2019).

can therefore be negligible in the case of an easy (BCP), 5% for a medium level of difficulty in a BCP for Spain-Portugal and between 38% - 73% for a hard level of difficulty in a BCP for Spain-France and around 20% for Lithuania-Poland.

4.6 Intermodal transport

This Section presents the cost structure and key profitability factors of intermodal transport. We examine a door-to-door[374] intermodal transport for three different intermodal transport modes: (i) rail/road, (ii) inland waterway/road and (iii) short-sea/road as requested by study question 9, and accompanied and non-accompanied intermodal transport as requested by study question 10.

4.6.1 Methodology and limitations

4.6.1.1 Methodology and limitations: unaccompanied intermodal transport types

To assess profitability of intermodal transport, the Consortium collected transport type-specific cost information from the publicly available literature and replies to the stakeholder consultation. Transport type-specific figures on revenues and profitability are not publicly available.

Estimates of the cost structure of the three types of intermodal transports (i) rail/road, (ii) inland waterway/road and (iii) short-sea/road operations have been published recently in the "technological fact sheets" included in the Annex of the latest PWC and KombiConsult (2022) report.[375]

Across the three intermodal transport types, distinctions are typically made in terms of:

- **Loading units (LUs)**, namely the unit used to transport the freight goods along the intermodal transport chain (e.g., containers, swap-bodies, semi-trailers, tractor units). The most commonly used loading unit in Europe is the 40'-container;
- **Transshipment technologies (TTs)** is the technology used to load the loading unit on the train/barge/ship from the truck, and vice versa (e.g. gantry crane, reachstaker, RoRO ramp to/from ship, mobile harbour crane, hydraulic material handling crane). The most commonly used TT in Europe is gantry crane. In the following, it is assumed that only one TT is used for the handling of the transshipment in the origin and destination terminals, and not a mix of TTs. This assumption is needed to ensure comparability of cost estimates across modes of transports and loading units. A mix of TTs would make costs estimates imprecise. In addition to that, the technical compatibility with LUs implies that not every mix of TTs is possible at both ends of the intermodal transport (PWC and KombiConsult 2022, p.26).

In the PWC and KombiConsult (2022) report, the cost structure is composed of seven cost items: costs of loading unit, costs of initial and final road legs, costs of first and second transshipments, costs of the main leg, and intermodal organisations costs. The initial and final road legs are assumed to be 75 km long each, 150 km in total, and are operated on road by trucks. The main leg is assumed to be 450 km long. A comparison on costs levels is done across the three types of intermodal transport, and allows to assess the competitiveness of each type depending on the type of transshipment technology adopted.

For the purpose of this report, the cost items per tkm estimated for these "standardised" distances are applied to the average distances of main leg and road legs reported for each type of transport in the ISL/KombiConsult report published in 2017. The report is based on data collection which includes official statistics, secondary sources as industry

[374] Cost structures and profitability factors for port-to-door intermodal transport for the three different combined transport modes is not considered in this section, due to scarce publicly available evidence and responses from Stakeholder consultation.

[375] The transshipment technology and loading unit used as base of the comparison are the most commonly adopted ones in the European terminals, according to Tables 32 and 33 of the DG MOVE report (i.e., gantry crane, reach staker, RoRO Ramp to/from ship, mobile harbour crane, hydraulic material handling crane).

associations or river commissions, and a survey among operators. This information is helpful to account for the additional dimension of distance, which clearly affects the costs of each mode of intermodal transport (as it is explained in section 4.3).

4.6.1.2 Methodology and limitations: Accompanied intermodal transport

Intermodal transport is said to be "accompanied" when semi-trailers are loaded together with the tractor on the train or other modes, and drivers travel along as passengers.

To assess the differences in terms of cost structure between accompanied and unaccompanied intermodal transport, information is taken from the "technological fact sheets" included in the Annex of PWC and KombiConsult (2022). This analysis also allows to compare the competitiveness of the different transshipment technologies adopted for accompanied intermodal transport. A review of the literature allows to complement the cost information with cost and profit drivers which are specific to accompanied transport.

A limitation to this Section is the absence of responses from the stakeholder consultation, which could have provided useful insight on costs, revenues and profitability of accompanied transport.

4.6.2 Findings

4.6.2.1 Unaccompanied intermodal transport types

Table 22 below reports the magnitude of the cost items for door-to-door intermodal transport[376] of a 40'-container loaded with a gantry crane.[377] The costs are calculated for the average distances reported for each type of transport in ISL/KombiConsult 2017: main leg is 615 km for rail/road, 222 km for IWW/road and 2,000 km for SSS/road. Total initial/final road legs are 204 km long for rail/road, 84 km long for IWW/road and 686 km long for SSS/road.[378]

Table 22: Cost structure for the three intermodal transport types for a 40' container transhipped with gantry crane TT

Gantry crane 40' container	RAIL/ROAD (€ per LU)	IWW/ROAD (€ per LU)	SSS/ROAD (€ per LU)
Cost of LU	3.1	2.7	24.8
First road leg	118.8	48.9	399.5
First transshipment[379]	44.2	26.4	215.7
Main leg	211.4	70.4	343.1
Second transshipment	44.2	26.4	215.7
Second road leg	115.2	48.1	387.5
Intermodal organisation	134.5	52.7	391.0

[376] The explanation of how each cost item is derived can be found in section 3.2.3 "Description of the fact sheet elements" of PWC and KombiConsult (2022), p.58.
[377] Cost structure for the other common TTs and LUs used in the European intermodal terminals are provided in Annex 27. These cost structures are built for door-to-door intermodal transports of 600 km, as it was done in PWC and KombiConsult (2022).
[378] The average distances for main leg and road legs of the three combined modes of transport are reported in KombiConsult (2017), Table 3.
[379] Based on the terminal costs per year as well as the total terminal handling capacity per year the different cost elements per transshipment are calculated. These are yearly values for the total terminal investment costs (building and equipment incl. planning), maintenance costs, energy costs, personnel costs as well as ground costs per transshipment. The maintenance, energy and personnel costs per transshipment summed up provide the value for the total operational costs per transshipment.

Total per LU	671.4	275.7	1362.3
Total € per tkm	0.030	0.033	0.027

Source: The Consortium based on PWC and KombiConsult (2022) and on (KombiConsult, 2017). Note: Section 3.2.3 of the PWC and KombiConsult (2022) report explains in full detail how the cost items are estimated.

In Table 22, IWW/road has the lowest costs per LU, while SSS/road is the most expensive mode of transport. Rail/road intermodal transport falls in the middle. However, the total costs per LU do not take into account the distance dimension and do not allow for a consistent comparison across the three modes of transport. Cost figures for IWW/road intermodal transport refer to relatively short main leg and road legs (respectively 222 km and 84 km), while the data for SSS/road refer to a door-to-door transport of 2,686 km in total (2,000 km of main leg plus 686 km of initial/final legs). It is clear that the comparison of the total costs per LU of the two transport types is not meaningful. Once distance is taken into account by calculating a €/tkm measure, the last row in Table 22 presents the opposite picture: SSS/road transport appears to be the cheapest type overall, followed by rail/road. IWW/road is the most expensive. This can be seen in the last row of Table 22, which reports the total costs per tkm for the three sub-categories of intermodal transport: 0.030 €/tkm for rail/road; 0.033 €/tkm for IWW/road, and 0.027 €/tkm for SSS/road.

The cost per tkm for road legs does not vary across the three types, and it is approximately equal to 0.042 €/tkm. This is a direct consequence of the assumptions used in PWC & KombiConsult (2022) to build the "technological fact sheets." In reality, SSS/road is the type of intermodal transport with the highest costs per road legs. This is because road legs are on average longer for short sea transport, given that ports and loading points of containers are generally more distant from the final transport destinations than for rail and inland waterway. This has also repercussions on another cost component of the road legs, which is not directly accounted in the table above: the time. Together with the waiting time of the truck in the terminal, additional time is due to the pick-up of empty container from depot locations before the loading of the goods (or for the return of the container at the arrival). This contributes to increase the costs of initial and/or final legs in a different way than for rail/road and IWW/road.

The costs structures presented in Annex 27 are built on fixed distances of the road and main legs for the three transport types, and allow to derive additional insights with a higher level of comparability. For example, the cost structure for a "standardised" 600 km door-to-door intermodal transport (with 75 km per each road leg)[380] of a 40'-container loaded with a gantry crane shows that short sea/road is the cheapest combined transport mode overall and has the lowest costs over the main leg of the transport. Inland waterway transport features the highest total cost because of high transshipment cost. Rail/road operations have the highest costs for the main leg, but fall in the middle of the three modes for the total transport cost.

Taking into account the transport costs for 40'-containers transshipped with gantry cranes (Table 22) and all other LUs and TTs listed in the tables included in Annex 27, the cost structure for the three transport types (Rail/road, IWW/road and SSS/road) can be summarised as follows:

- The cost of initial and final road legs ranges between 12-19% of the total cost of transport;
- The cost of two terminal transshipments (after the first and before the last mile road transport) range between 12-30% of total cost of transport;
- The main leg has the highest cost share and ranges between 17-38% of the total cost of transport;
- The cost of the LU ranges between 0.5-2.6% of the total costs of transport;

[380] The explanation of how each cost item is derived can be found in section 3.2.3 "Description of the fact sheet elements" of PWC and KombiConsult (2022), p.58.

- Intermodal organisation costs are set by definition as 25% of the sum of all other types of costs. In practise, these costs are likely to be fixed, but vary widely depending on the contract complexity.

The magnitude of these figures is consistent with the responses to the stakeholder consultation provided by a railway undertaking. A respondent indicated that, for a port-to-door domestic route, the cost of rail leg represents 51.5% of total costs, initial or final leg represents the 28.53%, and the terminal handling costs represent the 20%.

The comparison between the different combinations of TTs and LUs (in Annex 27) shows that, in the vast majority of cases, gantry crane is the TT with the lowest total costs of transport for all the three intermodal transport modes. The exception is the TT hydraulic material handling crane, which is cheaper than gantry crane for 20’ containers transported by IWW/road and SSS/road intermodal transport modes. The convenience of gantry cranes is also confirmed in the case studies reported in the Annexes Annex 15 to Annex 18, where this TT is used across all terminals under examination.

After discussing the cost structure of the three modes of intermodal transport, we now present evidence on profitability. Figures on revenues and profit margins are not publicly available. However, the literature and replies to the stakeholder consultation provide indications of the overall profit margin in the intermodal transport sector, which is generally known to generate low margins. UIC (2020b) reports that the net profit margin for intermodal transport actors is often below 1.5%, and that some undertakings are even loss-making (UIC 2020b, p.35). The results of the stakeholder consultation provide additional estimates. Two replies are available from inland waterway intermodal operators: an operator reported profitability before taxes between 10 and 20% of revenues, the other indicated 2-2.5% in a normal business year, 3-3.5% in a particularly productive year, or -4 to -6 % in an unfavourable business year. Finally, KombiConsult et al. (2015) reported an approximate 15% of margin for IWW/road transport.[381]

In addition, we investigated the key factors affecting the profitability of the intermodal transport types. The stakeholder consultation sent to market regulators, inland waterway operators and RU requested their views on these factors. Table 23 below collects the responses received.

Table 23: Stakeholder consultation responses on key profitability factors for intermodal transport types

Respondent	Rail/road	IWW/road	SSS/road
Regulator (Sweden)	Distance; distance to nearest terminal; competition from road; freight capacity; fill rate. Minimum distance of 350km to achieve break-even.	N/A	N/A
Regulator (#2)	Low cost; large volumes; suitable for long distance; eco-friendly.	Low cost; large volumes; eco-friendly	Low cost; large volumes; foreign trade contact; best for bulky goods; eco-friendly.
Railway undertaking (#1)	Length of the initial/final leg of trucking: this can make the rail leg very short. Other parameters as natural obstacles (e.g., mountains, sea,…) can also positively influence the balance in favor of rail.	N/A	N/A
Railway undertaking (#2)	Lower barriers to use intermodal transport due to the requirement that all trailers etc. to be cranable; Lower costs of pre- and on-carriage (e.g. by freeing it of road toll	N/A	N/A

[381] KombiConsult et al. (2015). Section 4.3.4, p.193.

	costs); Ensure sufficient capacity of terminals; Automation of rail and terminal service; Enable longer trains (740m/1500m).		
Inland waterway operator **(Austria)**	N/A	Weather conditions (e.g. low water, ice..)	N/A

Source: The Consortium based on responses to the stakeholder consultation sent to railway undertakings, inland waterway operators and market regulators.

The responses collected in Table 23 show some similarities across respondents. In particular, the length of the main leg versus the initial/final road legs is often considered a crucial factor for profitability in intermodal rail/road transport. This is consistent with findings in literature on the subject, as discussed in Section 4.4: Longer road legs mean higher rail leg distances are needed for the rail services to be cost-covering.

For inland waterways and short sea shipping, the most relevant factor is instead the volume of freight. These views are in line with the available literature. KombiConsult et al. (2015) describes the length of the initial/final road legs as a "critical cost factor for continental CT rail/road operations". The same report indicates economies of density, vessel size, and transport distance as profitability factors for the inland waterway/road services.

CONCLUSIONS:

The data collected for intermodal transport show that out of the three types of intermodal transport (short sea/road, inland waterway/road, rail/road), short sea/road journeys have the lowest overall cost per tkm and the lowest costs of the main leg. Inland waterway transport features the highest total cost per tkm due to high transshipment costs and short average distance. Rail/road operations have the highest costs for the main leg, but fall in the middle of the three modes for total transport cost per tkm.

Little public information is available on margins. Responses to the stakeholder consultation, together with triangulation of data and literature, indicate a potential range of 2-20%.

Respondents to the stakeholder consultation considered the length of the main leg versus the initial/final road legs a crucial factor in ensuring profitability in the intermodal rail/road transport. For IWW/road and SSS/road, the most relevant factor for profitability is instead the volume of freight.

4.6.2.2 Accompanied and non-accompanied intermodal transport

Intermodal transport is said to be "accompanied" when semi-trailers are loaded together with the tractor on the train or other modes, and drivers travel along as passengers. Here we focus on rail-road accompanied transport only, which is operated on "rolling motorway" (RoMo, also known as "rolling highway") and "rolling road" (also known as RoLa, "Rollende Landstraße"). Accompanied rail transport typically exists where there are unavoidable obstacles for road transport such as sea or mountains and it represents a small proportion of intermodal transport in Europe (6% of tonnes transported by intermodal transport).[382] The three examples[383] of accompanied rail-road services which are the most well-known in Europe are: the RoLa in Austria, the Eurotunnel between France and the UK, and the Swiss Gotthard Tunnel.

Danielis et al. (2010) explain that RoMo routes are more successful in countries where political support for rail is strong (e.g. Switzerland or Austria). They also list several

[382] See Figure 1, page 2 of UNCE (2018). Railways role in intermodality and the digitalisation of transport documents.

[383] "Autoroutes ferroviaires alpines" (AFA) between France and Italy also offer accompanied transport. However, this is rather exceptional. Indeed, 90% of AFA operations correspond to unaccompanied transport. It was 85% in 2015, and 70% in 2012 (see SA.51559 & SA.51714 and previous SA decisions). Another rolling road is operated between Italy and the UK: Orbassano (Turin) - Calais. However, only non-accompanied services are offered on this route. (see https://www.viia.com/).

technical constraints when using RoMo instead of non-accompanied rail-road transport. First, the railway gauge must allow 4m heights to pass trucks, which it is not the case in southern Europe and Great Britain. Second, the transport of a whole truck causes deadweight loss, because not only the freight, but also the truck itself needs to be transported. The total weight of a semi-trailer is 38 tons. Third, RoMo requires the use of shorter trains. In Switzerland in 2005, an estimation shows that the average RoMo train carried 15 trucks, whereas the non-accompanied one can accommodate almost 3 times as many semi-trailers. Fourth, RoMo are also less energy efficient than non-accompanied transport. Compared to road, non-accompanied intermodal transport brings a 29% energy saving, while RoMo routes save only up to 11%.[384] Finally, as highlighted in the State aid decisions SA.40404 and SA.39606, RoMo may require additional traction in the form of double locomotives, which significantly increases the cost of the service, or the additional administrative costs when the route is operated between two countries with different normative rules at the border. This is the case of the Autoroutes ferroviaires alpines (AFA) between Italy and France.[385]

The main difference in the cost-revenue structure between accompanied and non-accompanied intermodal transport is costs, which are higher for accompanied transport. DG MOVE (2022) provides the cost structure for both non-accompanied and accompanied services in Europe. Table 24 presents cost items for two different transshipment technologies used for accompanied transport, the RoLa ramp and the Flexiwaggon, and compares them to the costs for non-accompanied intermodal transport.[386]

Table 24: Cost structure for accompanied and non-accompanied transport

	RoLa TT (€)	Flexiwaggon TT (€)	Gantry crane TT (€)
	Accompanied		Non-accompanied
Cost of LU	92.3	84.83	14.45
First road leg	89.04	81.66	87.66
First transshipment	19.73	13.13	36.42
Main leg	502.19	442.99	185.35
Second transshipment	19.73	13.13	36.42
Second road leg	85.35	77.97	83.42
Intermodal organisation	202.09	178.43	110.93
Total	1010.43	892.15	554.66

*Source: PWC and KombiConsult 2022. Comparative evaluation of transshipment technologies for intermodal transport and their cost. Note: * For accompanied, the LU is a truck. For non-accompanied, the LU is a semi-trailer in this case. The initial and final road legs are assumed to be equal to 75 km each. The main leg has therefore a 450 km length. Section 3.2.3 of the DG MOVE report explains in full detail how the cost items in Table 24 are estimated.*

In accompanied transport, the cost of the loading unit is 6-6.5 times more expensive and transshipment costs are 2-3 times less expensive than for non-accompanied transport. Costs for the road legs are equivalent in both cases, which makes sense since this part of the haulage is the same for both types of transport. The rail leg costs 2.5-3

[384] Figures from UIRR (2009). Annual Report. www.uirr.comwww.uirr.com.
[385] SA.40404 (2014 / N) - France and SA.39606 (2015 / N) - Italy - Aid scheme for the transitional Alpine railway motorway service. The additional costs characterising AFA are described in recitals 102-103. Available at: https://ec.europa.eu/competition/state_aid/cases/256238/256238_1724081_211_2.pdf.
[386] The RoLa ramp and the Flexiwaggon are both transshipment technologies used in accompanied combined transport. The RoLa is used in the Alpes and the Flexiwaggon is not yet in regular operational use but market-ready.

times more for accompanied transport. This is in line with technical constraints of RoMo trains, which carry fewer loading units and more weight.

In addition to these results, a study by Economica (2013) reveals that accompanied rail-road services in Austria are not profitable/cost-covering. Indeed, due to the additional costs of transporting entire trucks and their drivers as well as their cargo, it is fundamentally difficult to achieve cost recovery on the RoMo. In contrast to that, non-accompanied intermodal transport can be cost-covering. In Austria in 2012, this was the case for transit services on distances above 200 km. The study also reports that subsidies can make non-accompanied services with block trains and accompanied RoMo services profitable, though the RoMo operations need almost 2 times more subsidies than block trains to cover costs.

In line with previous results, the Hupac Annual Report (2008) shows that RoMo accompanied trains run on lower average distances than non-accompanied intermodal transport (300 vs 800 km), require twice as much in investment per wagon, four times as much for maintenance, and three times as much in subsidies.

CONCLUSIONS:

The data collected for accompanied intermodal transport shows that it is significantly more costly than unaccompanied intermodal transport. The cost of the loading unit is 6-6.5 times more expensive, and the rail leg costs 2.5-3 times more (while the costs of the road legs are equivalent). Only transshipment costs are 2-3 times less expensive than for non-accompanied transport. This is consistent with the technical constraints of accompanied trains, which carry fewer loading units and more weight (since their weight also includes the tractor unit of the truck).

4.7 Price elasticities

To complement the presented cost and revenue data for rail freight transport, the Consortium also assessed demand elasticities. We find that the price elasticity of demand for block trains tends to be low. Similarly, we find lower elasticities for freight categories that are typically transported in bulk, e.g. steel and mineral fuels. As regards other goods, and both intermodal and single-wagon transport, we find higher elasticities, likely due to competition from road. However, the range of estimates in these segments is high.

4.7.1 Methodology and limitations

The Consortium collected elasticity estimates from the literature, actively approached institutions and authorities for further non-public research reports, and analysed responses from railway undertakings to the stakeholder consultation, enquiring about the expected change in volume following a hypothetical decrease in rail prices.

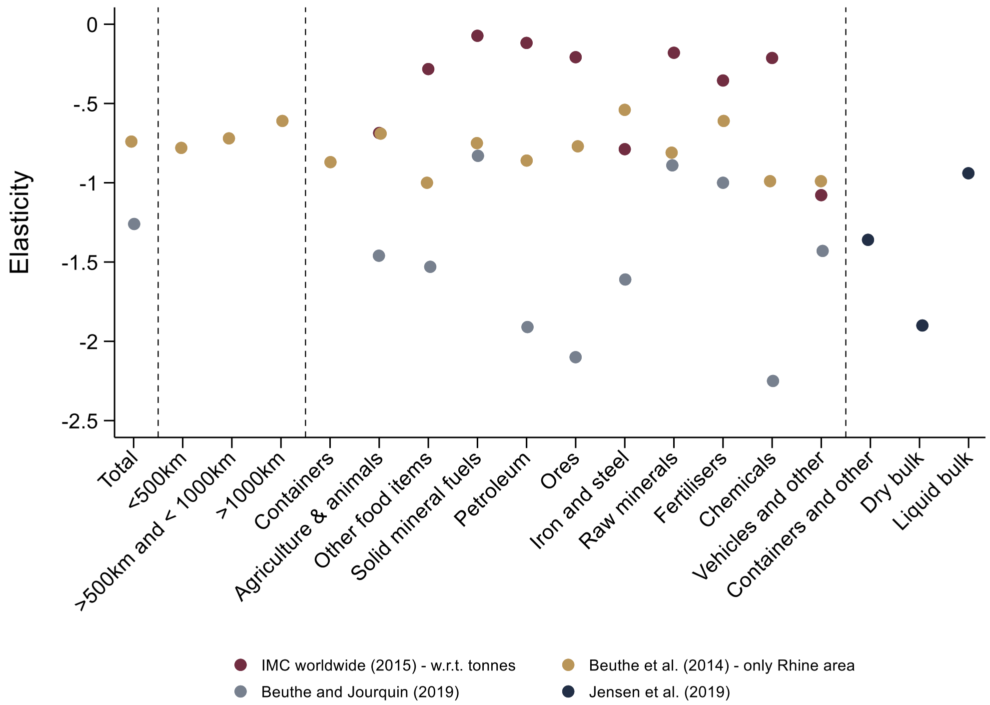
Due to the overall low share of rail in total transport volume, the rail price elasticity with respect to total transport demand is close to zero (IMC Worldwide 2015, p. 108 and Significance 2018, p. 20). Instead of reducing transport activities altogether, price increases induce some customers to switch from rail to other modes. Therefore, the literature generally focuses on elasticities with respect to *rail* transport volume or the modal share of rail.

There are commonly two types of sources that provide freight transport elasticity estimates. First, academic papers that make use of transport and network models as well as statistics on an aggregate level. As transport models and public statistics are often at the freight-category level, these studies often differentiate within this dimension. Second, reports commissioned by regulators or infrastructure managers that estimate elasticities to determine Ramsey-Boiteux prices of track access charges. These often rely on stated or revealed preference surveys on mode choices. In both cases, the second step is usually to estimate a choice model, e.g. a multinominal logit, and calculate elasticities based on the arising model coefficients.[387]

4.7.2 Findings

This Section discusses our findings on elasticity estimates in detail. Figure 36 provides an overview of elasticity estimates from studies with a supranational scope.

Figure 36: Price-elasticity estimates of rail demand in Europe



Source: See legend, compiled and visualised by the Consortium. All estimates with respect to tkm unless legend explicitly indicates otherwise.

An unsurprising result is that elasticities of rail (and waterways) decrease with larger distances (Beuthe et al. 2014). The reason for this seems to be a gradual decline in competition from road as transport distance increases. In particular, the cross-elasticity of road with respect to rail is higher than the one for waterway, though it decreases with distance. Conversely, the competitive pressure that waterway exerts on rail increases at higher transport distances.[388] Moreover, there is a significant amount of variation in the elasticity estimates between freight categories.

Figure 37 displays elasticity estimates from studies that distinguish freight categories using the NST/R classification.[389] Figure 38 exhibits elasticities predicted from a meta regression based on the same input data. This analysis considers study- and freight

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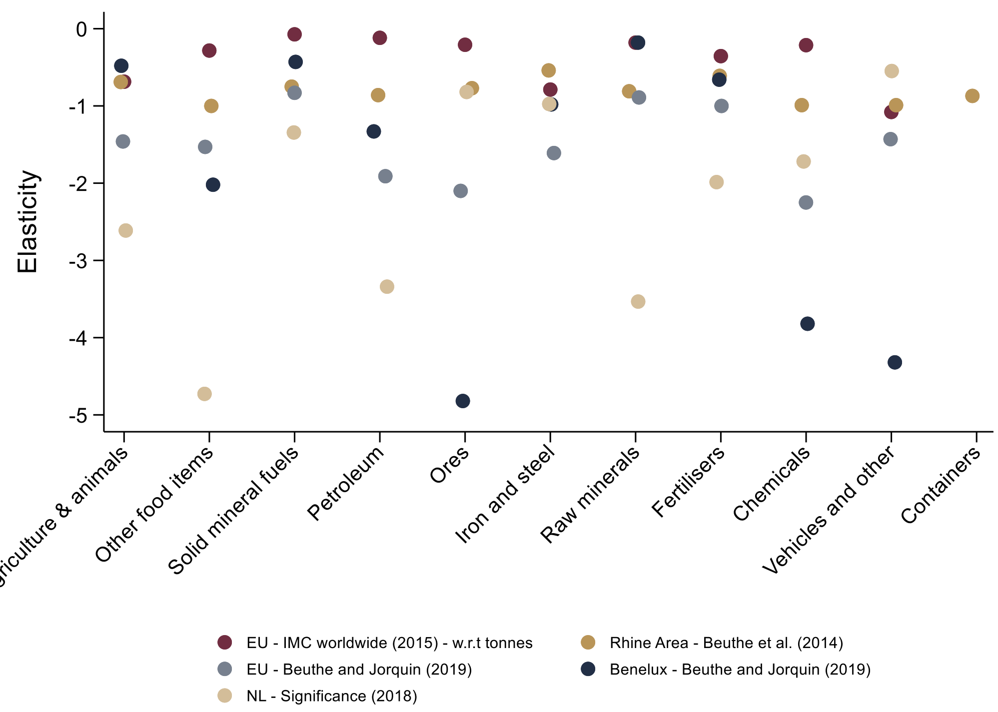
[387] The main difference being that the former type of study estimates aggregate choice models while the latter typically uses micro-level choices of (in the case of stated preferences: hypothetical) decisions. These methodological differences contribute to explaining the large variety of estimates presented in the remainder of this Section.
[388] See also Beuthe and Jourqin (2019).
[389] The NST/R classification is a superseded classification system for transport statistics, see https://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_NOM_DTL&StrNom=NSTR_1967&StrLanguageCode=EN&IntPcKey=&StrLayoutCode=HIERARCHIC. See Annex 28 for elasticity estimates of a Flemish study using the more recent NST 2007 classification.

category-specific effects in order to derive point estimates of elasticity for each freight category.[390] This facilitates comparisons of elasticity levels by freight categories.

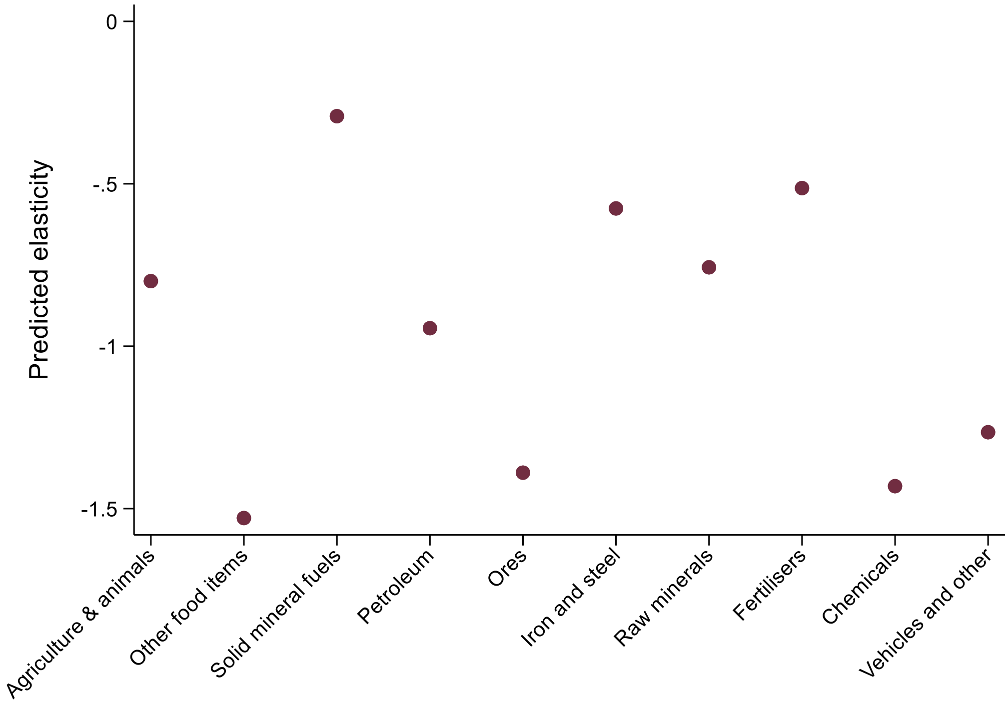
Figure 37: Price elasticity estimates of rail demand by NST/R classification



Source: see legend, compiled and visualised by the Consortium. All estimates with respect to tkm unless legend explicitly indicates otherwise.

390 More precisely, we estimated a meta regression with fixed effects of NST/R categories, countries and studies. The displayed elasticities reflect the average of predictions for two studies with a pan-European scope using the NST/R classification. The regression results are displayed in Table 105 of Annex 28.

Figure 38: Predicted price elasticities of rail demand by NST/R classification



Source: The Consortium based on the same sources as in Figure 37; the predictions are based on estimated coefficients of the model presented in Table 105 of Annex 28. They reflect the average of predictions for studies with a pan-European scope employing the NST/R classification.

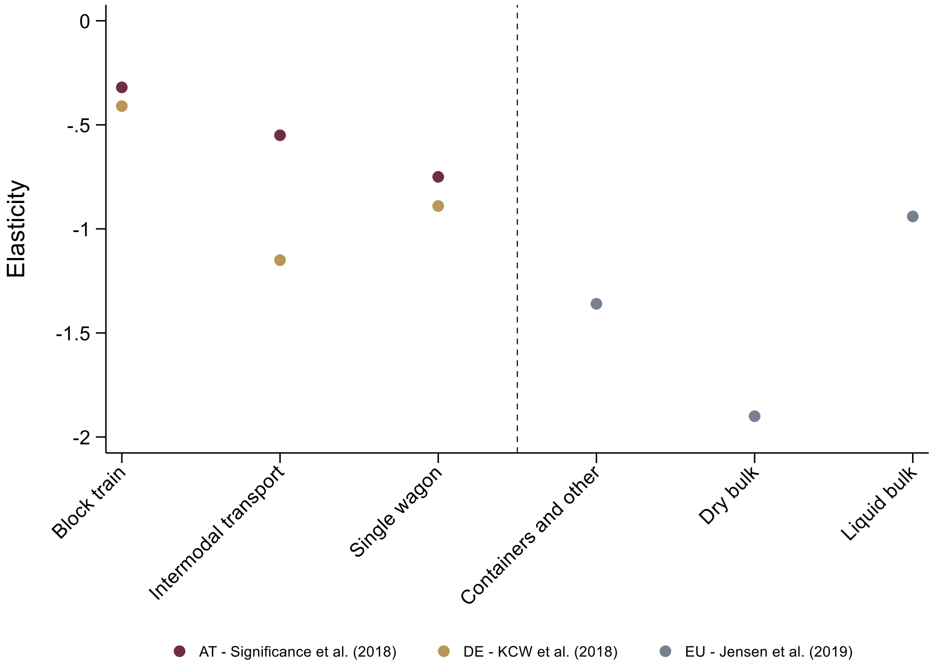
Both figures illustrate a large variation across freight categories *and* across studies. Nevertheless, the exhibits allow us to infer some general tendencies with caution. Largely, the three categories *Solid mineral fuels* (NST/R 2), *Iron and steel* (NST/R 5) and *Fertilisers* (NSTR/7) exhibit lower elasticities than the other goods and the range of estimates is reasonably close. These categories mainly comprise of the bulk goods which are frequently transported in large quantities via block train.[391] Conversely, elasticities for rail transport of goods such as food (NST/R 1) and vehicles (NST/R 9) tend to be higher, likely because they face strong competition from road.

The substantial spread of estimates in some categories is salient. Besides methodological differences, a potential explanation for this spread is the heterogeneity of the goods in the aggregated classes in conjunction with different product mixes in the respective geographical regions. For instance, the category *Vehicles and other* (NST/R 9), includes both machinery and leathers and textiles, and the elasticities between those sub-segments may vary considerably. Nevertheless, all these products are aggregated in the presented elasticity estimates. It is therefore possible that the visible differences in Figure 37 might be driven by particular product mixes that differ between countries (or even between different points in time).

Figure 39 depicts our aggregated elasticity estimates for different train types from three studies.

[391] Beyond the base estimates in Figure 37, Significance (2018) considers alternative scenarios and also distinguishes between domestic and international transport, see Annex 28.

Figure 39: Price elasticity estimates of rail demand by train type



Source: see legend, compiled and visualised by the Consortium. Jensen (2019) estimates with respect to tkm. KCW et al. (2018) and Significance et al. (2018) estimates with respect to modal choice.

Interestingly, both of the studies that follow our definition of *train types* (displayed on the left), indicate consistent elasticities for block train and single-wagon transport.[392] For block trains, the low elasticities are likely the consequence of economies of scale generated by moving bulk goods by train, alongside the reduced competitiveness of road transport. Therefore, a moderate increase in rail prices may induce only a small minority of customers to switch to alternative modes. Two out of three responses from the stakeholder consultation confirm that block train price reductions would not attract volume from road.[393] However, intra-mode competition seems more prevalent. Four out of five railways undertaking replied that a price reduction would lead to an increase in the volumes attracted from other railway undertakings.[394]

Conversely, the higher elasticity estimates for single-wagon and intermodal transport in Figure 39 can be explained by the fact that road transport is likely a competitive substitute for these train types to which customers are willing to switch.[395] A large difference in the elasticity estimates for intermodal transport between the studies might be explained by there being a significant share of accompanied intermodal transport in Austria, which has no competitive substitutes. In Germany, intermodal transport is likely to be more constrained by competition from road.

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[392] A comparison of KCW et al. (2018) and Significance et al. (2018) is particularly useful because both studies follow a similar methodology. More specifically, both collect stated preferences in hypothetical scenarios and calculate elasticities based on estimation of a logit model. KCW et al. (2018) also assesses very specific segments. For instance, they show that the demand elasticity for heavy block trains and the transport of dangerous goods is very low, see Annex 28.

[393] However, one respondent stressed that the cross-elasticity of block trains with respect to inland waterway plays a role.

[394] However, they also hint at inelastic demand. More specifically, LOTOS, a Polish challenger, indicated that a price reduction of 10% would attract 5% of additional volumes from other undertakings. Another anonymous railway undertaking puts that value at only 1%.

[395] Indeed, three out of three responses from the stakeholder consultation imply that a reduction of single-wagon prices would capture additional transport volume from road. As regards intra-mode competition, Lotos indicates higher elasticities for single-wagon and combined transport than for block trains. More specifically, a 10% price reduction would engender, respectively, a volume increase of 10% for combined transport, and of 15% for single-wagon. Bundesnetzagentur (2022) reports that respondents to a German market survey assess the single-wagon demand elasticity to be -0.6 on average.

In a European-wide study, Jensen et al. (2019) differentiate between liquid bulk and dry bulk on the one hand (mostly transported by block trains) and containers including others goods on the other hand (likely transported via single-wagon or intermodal transport operations). However, the resulting elasticity estimates do not align with the other studies. This may be due to differences in geographical scope and the fact that the link between freight category and train type is not perfect. However, it suggests the distinctions can be drawn between liquid and dry bulk, perhaps even within the block train segment.

CONCLUSIONS:

The available literature suggests that price elasticities for most bulk goods tend to be low. Likewise demand for block trains is mostly inelastic. In many cases, State aid for these segments might not be necessary. Elasticities for other freight categories, single-wagon and intermodal transport tend to be higher, due, among other reasons, to strong competition from road. State aid in these segments could prove helpful to increase transport volume on rail. Table 25 summarises these findings by grouping segments.

Table 25: Grouping of Elasticities

(absolute) Elasticity	exemplary segments	spread of estimates
low	block trains, solid mineral fuels, iron and steel, fertilisers, dangerous goods, high-distance trains	generally low
medium to high	single-wagon, intermodal transport, food, vehicles, containerised goods, low-distance trains	high

Source: The Consortium.

4.8 Operating State aid

State aid for operating rail freight services foreseen in the Guidelines can cover the cost of infrastructure use, the reduction of external costs or the costs of starting new services by start-ups.[396] Its duration is limited to 5 years. It is presumed necessary and proportional if it is lower than 30% of the total cost of rail transport and up to 100% costs for infrastructure use (e.g. track access charges) or up to 50% of the avoided external costs.[397] The Guidelines do not require ex-post evaluation of State aid schemes and do not propose any performance indicators or other evaluation criteria.

Within the state support database described in Section 1.4, operating aid was available under approximately half of all measures (46.15%, 48/104). Operating aid support at the start of the period was at least €230.15 million and at the end of the period was at least €1.10 billion. The total budget over the period was at least €5.23 billion.

We observed a high degree of diversity in the scope of aid offered. For instance, some Member States opted for general rail support schemes[398] whilst others chose to support a particular type of rail freight (for example single-wagon transport[399] or accompanied intermodal transport[400]).

[396] Railway Guidelines, section 6.
[397] Railway Guidelines, par. 107.
[398] For example, Denmark has been providing an operating aid subsidy to all rail freight transport operators which wish to claim it since 1999. The subsidy aims to offset the effects of rail infrastructure charges and promote a shift from road to rail transport operations. See SA.48634 '*Subsidy Scheme Rail Freight*' for more information. Available at https://ec.europa.eu/competition/state_aid/cases/270299/270299_1950845_105_2.pdf.
[399] For a further discussion of single wagon transport schemes see Section 4.2.3.
[400] For a further discussion of accompanied combined transport schemes see Section 4.6.2.2.

Equally, the level of subsidy often differed by type of route (for example offering a higher level of subsidy for mountainous regions[401] or a different level of subsidy for domestic routes than routes between ports[402] or specific subsidies for regions or routes[403]), or other factors (for example some schemes offer different rates of subsidy in the night/daytime[404], how the goods are loaded[405] or the punctuality of services[406]).

Two main types of subsidies were offered: 34 measures offered a subsidy to provide for external costs (34/48, 70.83%) and 15 measures refunded track access or other infrastructure charges (15/48, 31.25%). Note that these categories are not mutually exclusive.

4.8.1 Financial incentives for structurally loss-making rail freight services

We compiled a detailed database of State aid support schemes by Member State during 2012-2021 (see Section 1.4.1. Data on expenditure, duration, and aid type was gathered using, among other things, the available information in each State aid decision's text and the actual aid expenditures as published by the European Commission. This was then complemented with the information about State support for rail freight in Switzerland.

Next, we constructed a measure *subsidies per tkm* to assess the relevance of State aid granted in each Member State in 2019. To achieve this, the database was filtered by several criteria. First, the Consortium considered only State aid schemes that were both active in 2019 and benefitted rail freight transport. Whenever the information was available, the aid targeting rail freight transport specifically was separated from the aid destined for other modes of transport within the same decision. If possible, a further distinction was made between aid targeting intermodal and single wagon operations. Second, we analysed only State aid schemes designed to impact the beneficiaries' operational costs and, to the extent possible, disregarded investment aid. When the scheme involved both investment and operational aid and the decision's text did not allow for any separation, the overall State aid decision was still used for the computation of the metric.

In the process of estimating the measure, we had to address some data limitations. To begin with, the database includes only State aid schemes that were awarded directly by Member States. Therefore, we omitted programs co-funded by the EU such as the Eu-

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[401] For example, Austria offers a higher rate of subsidy for Rola operators in mountainous regions, to compensate for the increased external costs caused by road transport. See SA.55507 '*Austria – Amendment of the State aid scheme for the provision of rail freight services in certain forms of production in Austria 2018-2022, in relation to the rolling highway in mountainous regions* '. Available at https://ec.europa.eu/competition/state_aid/cases1/20203/283020_2123962_155_2.pdf.

[402] For example, under *SA.38611: Promotion of combined (intermodal transport units) and distributed freight transport by rail,* Belgium offers a different rate of subsidy for shuttle trains between Belgian seaports and domestic combined rail transport. See https://ec.europa.eu/competition/state_aid/cases/254303/254303_1603723_82_3.pdf.

[403] For example in Italy there are a number of schemes which offer subsidies to particular routes or regions many of which are limited to a certain type of rail transport, one in the FVG Region is even limited by product, see *'SA.50115: Intermodal rail transport of iron slabs'* https://ec.europa.eu/competition/state_aid/cases/272838/272838_2051050_129_2.pdf.

[404] For example, Austria offers a different rate of subsidy to RoLa depending on if the transport takes place by day or night, see recital 24, *SA.33993 Austria – Aid for the provision of certain combined transport services by rail in Austria.* Available at https://ec.europa.eu/competition/state_aid/cases/242866/242866_1351150_121_2.pdf.

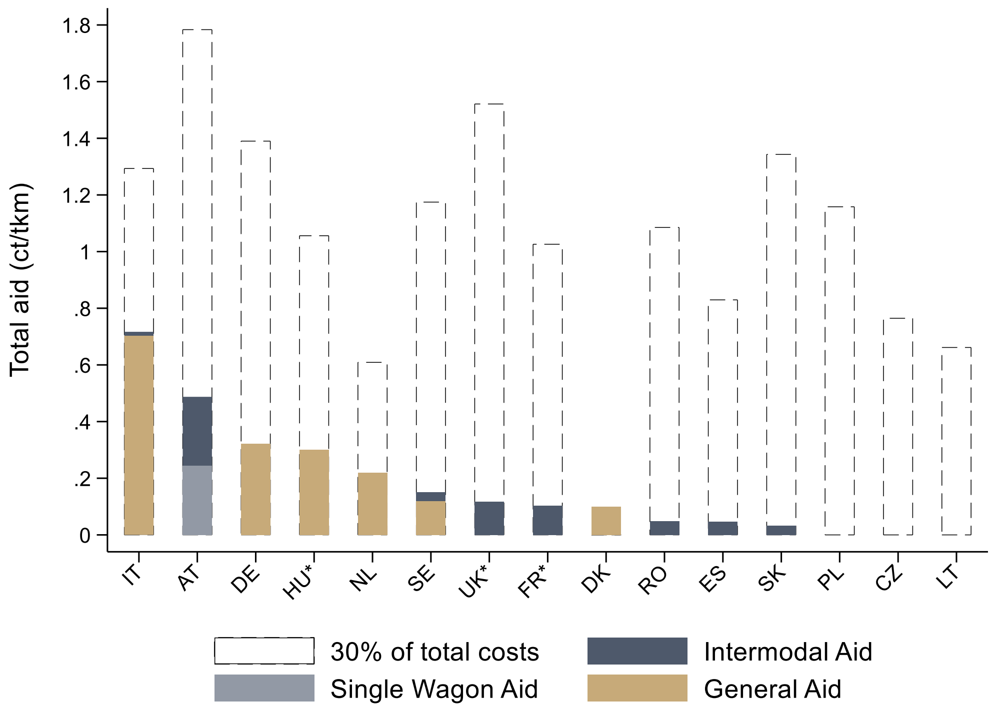
[405] For example, Luxembourg offers a lower subsidy to goods handled horizontally (€10 euros per ITU) rather than vertically (€30 per ITU) due to the lower costs of loading a semi-trailer on a rail motorway compared to loading a container on a train. See recital 22 of SA.38229 *'Luxembourg Aid for the promotion of combined transport for the period 2015-2018'.* Available at https://ec.europa.eu/competition/state_aid/cases/251592/251592_1663755_60_2.pdf.

[406] For example, if aid beneficiaries are not punctual under one scheme in Austria, they must pay a compensation fee. See recital 28 '*SA.33993 Austria – Aid for the provision of certain combined transport services by rail in Austria*.' Available at https://ec.europa.eu/competition/state_aid/cases/242866/242866_1351150_121_2.pdf.

ropean Regional Development Fund (ERDF). Additionally, information from national databases is not included. Finally, actual expenditure was preferred over budgeted expenditure. The latter, however, was used if data on the former was not available.

Figure 40 displays total subsidies per tkm in 2019 across Member States.

Figure 40: Subsidies per tkm by Member State and type of aid in 2019



*Source: The Consortium based on own calculations. Notes: * For France, Hungary, and UK, total revenues from IRG are used to proxy 30% of total costs. Revenues for France refer to 2018. Total costs or revenues for Denmark are not available. Volume figures for Belgium are not available. State aid figures for Switzerland are not available. Total State aid for Germany and France is overestimated due to overlap with investment aid or inclusion of other modes of transport.*

In 2019, the Member State with the highest level of total subsidies per tkm was Italy with 0.71 ct/tkm. [407] The second and third highest Member States were Austria and Germany with total subsidies of 0.48 and 0.32 ct/tkm, respectively. On the other end of the scale, Romania, Spain, and Slovakia awarded subsidies between 0.03-0.05 ct/tkm, all devoted to intermodal operations. Finally, our database indicates that some Member States such as Poland, the Czech Republic, and Lithuania did not provide any operating aid to rail freight transport in 2019.

In line with the current Guidelines, the aid amount that can be granted for rail infrastructure use and for reducing external costs without Member States demonstrating the need for and proportionality of the aid is 30% of the total cost of rail transport (see Section 4.8.2). The dashed lines in Figure 40 illustrate that all Member States granted a level of subsidies that was well below this threshold in 2019.[408] Notably, Italy, Austria, and Germany, respectively, reached a share of subsidies of 16.6%, 7.99%, and 6.91% of total costs.

Italy was the Member State with the highest amount of subsidies per tkm, covering 16.6% of total costs in 2019. However, Italy's rail modal share reached only 6.8%, a

[407] The two major schemes were SA.44627 and SA.45482, both targeting the overall rail freight sector and accounting for 24% and 68% of total aid, respectively.
[408] Given the low contribution of subsidies to total costs per Member State in 2019, the cost and revenue estimates provided in Section 4 are unlikely to be substantially biased.

value below the European average of 12% (refer to Annex 9.1 for more details), suggesting that the scheme had a limited impact.[409] As highlighted during the interview with FerCargo, a railway association in Italy, this may be explained by the fact that road transport is even more heavily subsidised.

In Austria, aid in support of single-wagon and intermodal operations was very high compared to other Member States, reaching 0.79 and 0.99 ct/tkm, respectively.[410] As Herry Consult (2020) reports, 32% of rail freight volume in 2015 was transported via single wagon,[411] proving the effectiveness of the State aid scheme in keeping single-wagon operations on the market. Furthermore, according to the same source, intermodal operations contributed 25% to the total freight volume transported via rail. For more details on intermodal aid, please refer to Section 1.4.2.

We also reviewed State aid decisions granted to the following unprofitable rail freight services:

Single-wagon transport is an inherently unprofitable service (see Section 4.2.3). According to Xrail, an alliance of RU offering single-wagon services, it "has lost significant market share to road and other rail freight transport modes despite the growing transport market. Many players have significantly downsized their networks or even dropped out of the market. "[412] The major reasons for this development are strong competitive pressure from road, intermodal traffic, and block trains; high technical and regulatory requirements, infrastructure bottlenecks, increasing track access charges, priority for passenger trains, and insufficient transparency, seamless offer, interoperability, flexibility, and the speed of innovation.

Within the State support measures database, we identified 5 schemes which offered specific subsidies for single-wagon transport and present them in detail below.[413]

Austria has awarded subsidies for single- wagon transport since at least 2012 (see SA.33993). The aid is granted per net tkm and its level is differentiated by type of traffic (domestic transport or import/export). It may be further broken down by distance categories. The scheme foresees a compensation fee if the beneficiary's service is not sufficiently punctual. Notably, the 2020 decision recorded lower production costs per 1000 tkm for single-wagon transport than unaccompanied intermodal transport across all categories (using 2015 data). This suggests that whilst single-wagon transport might be losing ground to intermodal transport on the whole due to its unprofitability, in Austria it was the more cost-effective rail freight service.[414] It is also notable that this scheme recorded single-wagon transport volume of 5,587 million net-net tkm in 2010 and 5,677 million net-net tkm in 2015, an increase in volumes of 1.61%.

Germany has offered specific support to single-wagon transport since November 2020 (SA.58046). It provides grants to RU active in single-wagon transport by subsidising access charges and in 2021 it offered an 87.67% reduction to access charges.

Hungary first ran a support scheme for single-wagon traffic between 2012 and 2017 (SA.33417) and offered a reduction in fees for the provision of shunting staff, provision of traction vehicles for shunting purposes and external train acceptance. In November 2021, Hungary renewed State support for single-wagon transport under a separate

[409] Tsamboulas et al. (2015) estimates that „Ferrobonus" – one of the two major State aid schemes contributing to the level of total subsidies in the country – successfully attracted demand for rail by creating an estimated modal shift of 1.13% in 2014.
[410] Both values are obtained by dividing the aid amounts with the respective volume figures by train type.
[411] Down from 41% in 2012 according to Economica (2013), Figure 8.
[412] https://www.xrail.eu/wagonload-challenges, accessed 5.5.2022.
[413] Note that single-wagon transport is often supported under broad rail subsidies, the purpose of this analysis was to identify subsidies offered to Single-wagon transport at a preferential rate. The beneficiaries of these subsidies are sometimes allowed to accept the subsidies in conjunction with other rail subsidies (cumulative aid) or must forfeit access to other subsidies to claim access to the preferential rates. In all cases, subsidies for single-wagon transport appeared to remain below the 30%/50% thresholds.
[414] Production costs (EUR/1000 tkm) were lower in three out of three categories: Domestic Transport (107.9 EUR/1,000 tkm SWT, 123.2 EUR/1,000 tkm UCT) Import/Export (65.6 EUR/1,000 tkm SWT, 79.8 EUR/1,000 tkm UCT) and Transit (37.4 EUR/1,000 tkm SWT, 83.4 EUR/1,000 tkm UCT). See SA.57371.

scheme (SA.59448) and revised the system to award non-refundable grants directly to railway undertakings.

In Belgium, specific support for single-wagon transport has been in place since at least 2012 (SA.38611). Most recently the measure was renewed in 2021 (SA.57556). Aid is awarded to single-wagon transport through an operating aid subsidy of 0.57 euro per wagon per km travelled.

In addition, the public consultation refers to single-wagon services as structurally loss-making and in the need of State support. MR and RU[415] also confirm in their replies to the survey that SW services do not achieve break-even point without State aid. In Spain SW is not offered, because it is not profitable. In Poland, exceptionally, an independent RU operates SW with a small profit as presented in Section 4.2.3. During the interview, the RU emphasised the availability of sufficient spare capacity in terminals, private sidings and marshalling yards as the key factor for profitable SW operations. This indicates that single-wagon transport is likely to benefit from State aid for infrastructure.

Accompanied intermodal transport is typically loss-making and requires subsidies to be offered. This is a result of competition with unaccompanied intermodal transport, which is more efficient due to higher load capacity: the weight and the length of the tractor does not need to be carried when non-accompanied. Thus, accompanied transport cannot pass all of its costs to the final customer. However, the data collected for accompanied intermodal transport shows that it is significantly more costly than unaccompanied intermodal transport (see Section 4.6.2.2 for details).

Within the State support measures database, we identified four instances of MS offering higher levels of subsidies to accompanied intermodal transport than unaccompanied intermodal transport.[416]

A study by the Swiss Federal Audit Office of 2018[417] compared the subsidies granted to the Swiss “rolling motorway” RoLa from Freiburg to Novara (414 km) and the Austrian RoLa from Wörgl to Brenner Passhöhe (95 km). In 2016, the operators of both services received State aid from their governments in almost the same amount of State aid of 0.74€/km (Swiss) and 0.75 €/km (Austrian) per shipment. In addition, the State aid scheme for Ro-La intermodal transport (SA. 39883)[418] in Romania clearly shows that State aid is needed to offer accompanied transport. Indeed, hauliers can be attracted to Ro-La services only if lower prices and shorter transport time are offered to them as compared to transport by road, but accompanied transport total costs were on average 45% higher than road total costs.

For most of the countries analysed in Section 4.2, conducting a neutral analysis on their level of subsidies in the context of the cost-revenue framework is not possible. For instance, Member States can declare the reception of subsidies either as a reduction of costs (e.g., reduction of TAC) or as a form of additional revenues, hence rendering the disentanglement of State aid unfeasible. Moreover, the cost and revenue estimates obtained in Section 4.2 can be expected to present a certain degree of bias and unreliability due to the indistinguishable presence of subsidies. Therefore, the Consortium computed the level of State aid per tkm approved by the European Commission for rail freight operations across Member States and related it to the rail freight costs as presented in Figure 40 above. This can help to achieve an understanding of the importance of subsidies in Europe. Not notified State aid is not covered in this analysis.

[415] From Austria, Germany, Poland, Spain, and Switzerland.
[416] Namely the Swiss scheme, Austrian schemes and Romanian schemes discussed in the paragraph below and the Italian state aid scheme supporting combined transport in the Province of Bolzano (SA.48858, and SA.5506) which did not include any relevant analysis.
[417] https://biblio.parlament.ch/e-docs/393381.pdf, accessed 6.5.2022.
[418] SA.39883 (2014/N) State aid scheme for RO-LA combined transport. https://ec.europa.eu/competition/elojade/isef/case_details.cfm?proc_code=3_SA_39883

CONCLUSIONS:

The level of total approved operating State aid per tkm was insignificant for most Member States in 2019. Consequently:

- Cost and revenue estimates in Section 4.2 can be considered not to be significantly biased;
- total operating State aid per tkm are well below 30% of the Member States' total costs; Therefore, the appropriateness of the threshold is difficult to evaluate;
- Notable exceptions are Austria and Italy. The former effectively keep single-wagon operations in the market, while the latter has difficulties fostering rail freight modal share despite a relatively high level of operating State aid.

Single-wagon transport and accompanied intermodal transport are typically unprofitable services which need State aid to be offered.

4.8.2 Thresholds for presumption of necessity and proportionality

In accordance with point 107(b) of the Guidelines, there is a presumption of necessity and proportionality for State aid aimed at reducing external costs if the aid intensity remains below 30% of total cost of rail transport and up to 50% of the eligible costs.[419]. Within the State aid database, we located 5 schemes in 4 MS where either of these thresholds were exceeded. These schemes and their justification for exceeding the thresholds are detailed in the table below.

Table 26: State Support Measures where the thresholds for presumption of necessity and proportionality were exceeded (2012-2021)

Member State, Scheme and State aid Number	Aid intensity threshold exceeded and maximum amount of excess	Reason and justification for excess
France and Italy ***'Aid scheme for the experimental service of the alpine rail motorway.'*** **SA.33845, SA.40404, SA.51559** **sa.34146, sa.39606, SA.51714**	Both thresholds 50% threshold: 65% (15% excess) 30% threshold: 65% (35% excess)	The scheme concerns transitional operating aid to an experimental Alpine rail motorway. A higher level of aid was envisioned in the first few years of operation to compensate for start-up costs and the railway line not operating at full capacity. As such, it is unsurprising that the aid intensity dropped significantly over time. In 2012, aid equalled approximately 65% of total costs. By 2019 this was within the 50% threshold. The 30% threshold was exceeded throughout the period. However, the level of excess also decreased.
France ***'Combined freight transport scheme.'*** **SA.37881, SA.53158**	50% threshold: 57.71% (7.71% excess)	The measure concerns support for intermodal freight transport in France, including rail, IWW, and SSS. Aid to intermodal IWW transport was offered at 57.71% of eligible costs. This was found to be proportionate as distances travelled with this mode of transport are shorter than those travelled by rail and that the tonnages transported are lower, due to the greater transport of empty containers.

[419] See 107(b) 'Communication from the Commission: Community guidelines on State aid for railway undertakings. Available at c_18420080722en00130031.pdf (europa.eu).

		The level of excess was the similar in 2014 and 2019.
Luxembourg ***'Aid for the promotion of combined transport'*** **SA.38229, SA.39883**	30% threshold: Not stated	The measure concerns aid for the promotion of intermodal transport in Luxembourg. 30% threshold is exceeded for national rail intermodal transport. This was accepted as these operations are over very short distances and therefore very expensive.
Romania ***'State aid scheme for ro-la combined transport'*** **SA.39883**	50% threshold: 60% (10% excess)	Romanian authorities argued that attracting road carriers to Ro-La services could only be achieved by setting Ro-La railway service transport tariffs at a comparable level to road transport costs and that the 50% of eligible costs would be insufficient to make the scheme attractive for railway operators. 60% of total costs of Ro-La was therefore deemed necessary to incentive a shift from road to rail.
Italy ***'Interventions in favour of the city of genoa'*** **SA.53615**	50% threshold: 54% (4% excess)	The measure concerns compensation for railway operators following a bridge collapse. Aid temporarily exceeds the 50% threshold whilst the bridge is being repaired.

Source: The Consortium.

We discuss each of the thresholds in detail below.

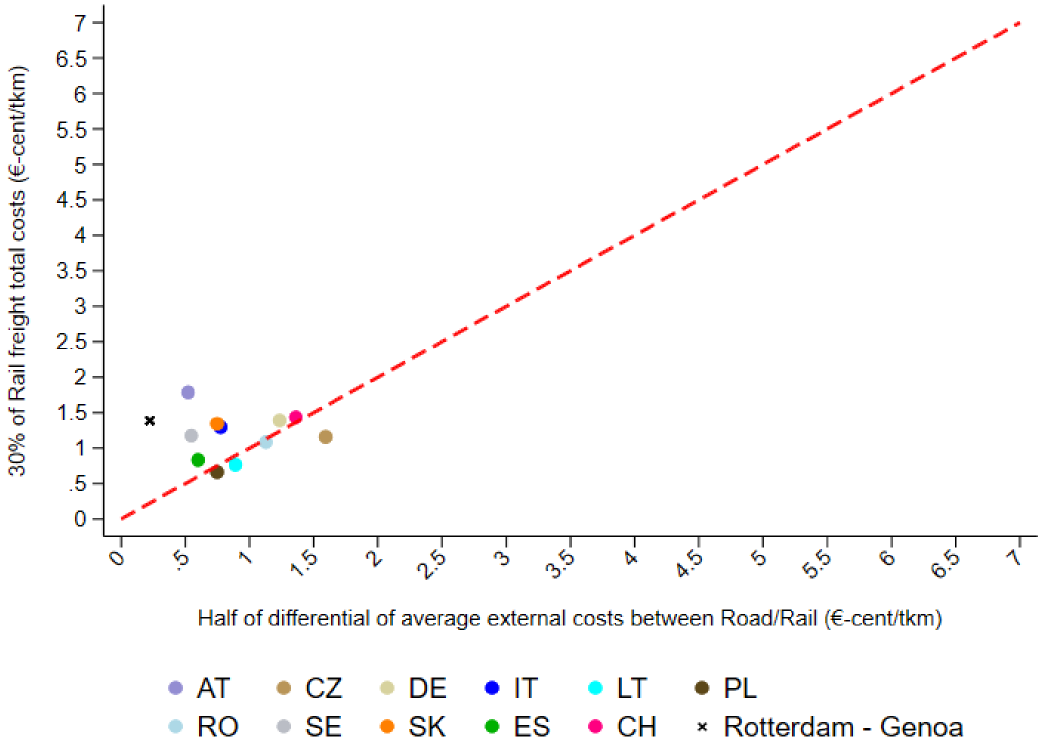
4.8.2.1 30% threshold for total cost

Authorities in EU Member States can grant State aid for rail infrastructure use and for reducing external costs under an assumption of necessity and proportionality at a low administrative burden as long as the amount does not exceed 30% of the total cost of rail transport. The Consortium has asked granting authorities in the stakeholder consultation whether they made use of this threshold when granting aid for rail infrastructure use and for reducing external costs and, if not, whether they considered a different threshold more appropriate. Unfortunately, none of the stakeholders provided informative answers.[420]

The only available view on the level of the threshold comes from a position paper by the Community of European Railway and Infrastructure Companies (CER, 2021) and supports the thesis that the 30% threshold is too low and should be shifted up to 60%. The increase of this threshold is argued as follows: (i) railway transport is characterised by extremely high fixed costs and by relatively short routes that do not allow for the full coverage of those costs. These two elements make it difficult for the rail freight sector to compete with road transport sector. (ii) The increase is presented as logical consequence of the proposed increase of the threshold of the eligible costs for the reduction of external costs. The CER proposes to double the percentage of eligible costs covered by aid for the reduction of external costs from 50% to 100%. If the threshold of total costs is not updated accordingly, it would hamper the effectiveness of the aid for the reduction of external costs. This is illustrated in the figure below, which compares 30% rail freight costs and 50% differential of external costs between rail and road.

[420] Four granting authorities replied to the consultation. The Swiss authority refrained from providing an answer and the remaining authorities from Austria, Germany and Lithuania did not grant State aid for the use of infrastructure or reduction of external costs and thus did not make use of the 30% threshold, so did not suggest that any other threshold was more appropriate. Note that the authorities from Austria and Germany were different from the authorities that offered State aid schemes listed in Table 26.

Figure 41: Comparison of 30% rail freight costs and 50% differential of external costs between rail and road



Source: Data from 4.2.2, annexes from CE Delf, 2019 and the annual reports for road transport market published by the Comité National Routier.

The 50% differential of external costs between rail and road is very similar or even exceeds 30% rail freight costs in multiple countries: Czech Republic, Germany, Lithuania, Poland Romania, Spain and Switzerland. Because both of these thresholds apply in setting the ceiling to aid intensity, they need to be increased together. It would not be possible to exploit the increased scope for subsidizing external cost differential if the 50% was increased, but the 30% threshold remained. The aim of the CER's proposal is to establish a level-playing field between different modes of transport. According to the CER, the current imbalance is created by the external costs not being allocated to the more polluting modes of transport (e.g. air and road transport). Funding up to 100% of the difference of the external costs between road and rail would set stronger incentives to promote a further modal shift, and would enable the sector to achieve the EU milestones for shifting freight transport towards more sustainable modes of transport.

The majority of the replies to the EC public consultation also indicate that the 30% threshold for total costs is too low, and is not sufficient to incentivise undertakings to enforce a modal shift from road to railway transport. An example mentioned in the replies is that, in some countries, track access charges alone represent 30% of total costs of railway transport. Most of the respondents suggested higher thresholds from 50% to 60%. A limited number of respondents proposed 100%, with reference to the Eurovignette. Such thresholds could incentivise stakeholders to develop rail freight or intermodal services.

The review of past State aid decisions provides potential further insights on the effectiveness of the 30% threshold. In 2015, the EC approved the aid scheme SA.39883[421] at 60% aid intensity to incentivise the offer of accompanied Ro-La intermodal transport

[421] A.39883 (2014/N) State aid scheme for RO-LA combined transport. https://ec.europa.eu/competition/elojade/isef/case_details.cfm?proc_code=3_SA_39883.

services and reduce the adverse impact of road transport on the environment in Romania. At 60%, the aid intensity reflected the cost difference between the road costs and total costs of accompanied transport, as submitted by the Romanian authorities. Such aid might be considered proportional without further examination. In 2015, the EC also approved two other aid schemes for accompanied transport with an aid intensity exceeding the 30% threshold: SA.40404 and SA.39606[422] aimed at financing the Alpine rolling highway between Aiton (France) and Orbassano (Italy). Thus, it appears that at least in accompanied transport the current 30% threshold is not sufficient. This is consistent with the fact that accompanied transport is generally not profitable, as also discussed in Section 4.6.2.2.

4.8.2.2 50% threshold for external cost

According to current rules, the aid for reducing external costs is presumed to be necessary and proportionate if it does not exceed 50% of the eligible costs. These eligible costs are the part of the external costs which rail transport makes it possible to avoid, as compared with competing transport modes. To assess by how much the eligible costs differ from the total costs of rail freight, and whether such aid intensity is sufficient to make rail freight competitive against road freight transport, the Consortium compared (i) the cost of rail freight services and (ii) the half of the external cost differential (with respect to the external cost of other modes of transport).

Rail service costs are compared to the estimates of external costs contained in the annexes attached to the “Handbook of External costs of modes of transports”, published by the European Commission in 2019.[423]

The comparison is visualised by Figure 42 with scatter plots, where each dot represents a country:

- the x-axis represents 50% of the external cost differential with respect to the external cost of other modes of transport (e.g. differential between road and rail)
- in the left panel, the y-axis reports the average total cost of the freight service in ct/tkm
- in the right panel, the y-axis reports the differential of average total cost of freight services between rail and road in ct/tkm[424]

All countries for which cost data was available were analysed using data collected and/or estimated by the Consortium in the context of Section 4.2.2. These countries were: Austria, Czech Republic, France, Germany, Italy, Lithuania, Poland, Romania, Sweden, Slovakia, Spain and Switzerland. The costs of freight road services for Switzerland and Sweden are currently not available. These countries are therefore the countries missing from the graph on the right side of Figure 42.

In Figure 42, the 45-degree line represents the points where the half of the external cost differential between road and rail is exactly equal to the total costs of the rail freight service (left panel) or to the differential of average total costs of freight services between rail and road (right panel). For the dots above the diagonal line, the half of the external cost differential between the two modes of transport is lower than the parameter on the y-axis, while below the diagonal line the opposite is true.

The graph on the left side of Figure 42 shows that for these eleven countries, the average eligible costs are lower than the average total cost of the rail freight service. In the case of Austria, Germany, Slovakia and Switzerland, the difference is particularly large,

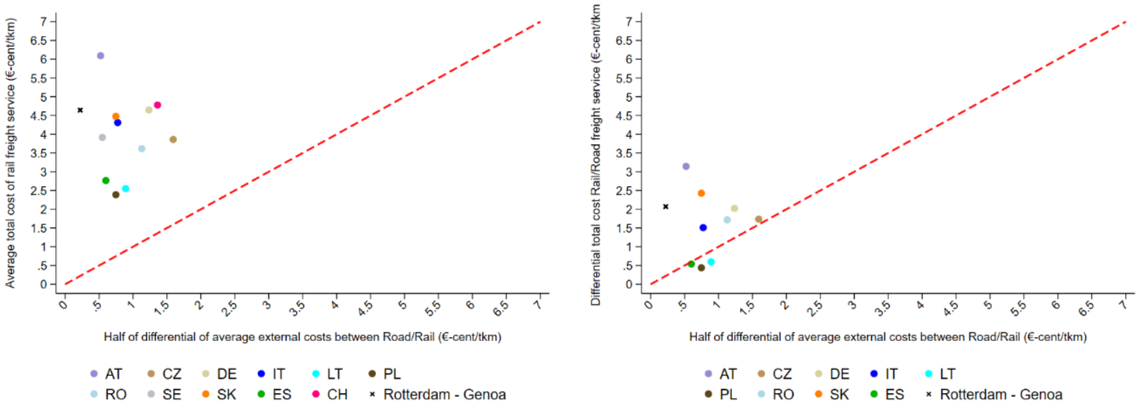
[422] SA.40404 (2014/N) – Francia e SA.39606 (2015/N) – Italia Regime di aiuto al servizio transitorio di autostrada ferroviaria alpina. https://ec.europa.eu/competition/state_aid/cases/256238/256238_1724081_211_2.pdf.

[423] The annexes of the report record the estimates of the average total external costs split by country and by transport mode. Total external costs are calculated as the sum of costs for accidents, air pollution, climate change, noise, congestion and habitat damage. The data is available for all 27 Member States and Switzerland. The estimates are recorded in the unit measure of Eurocent/tkm and refer to the year 2016.

[424] The figures for average total costs of road freight transport are extracted from the reports published by the Comité National Routier. Available at: https://www.cnr.fr/en/publications (accessed May 04, 2022).

indicating that State aid for eligible costs covers only a relatively small share of the cost of rail freight transport.

Figure 42: Comparison of freight service costs (left), cost differential between rail and road (right) vs half of differential of external costs between rail and road



Source: Data from 4.2.2, annexes from CE Delf, 2019 and the annual reports for road transport market published by the Comité National Routier.

The right panel of Figure 42 reports the differential of average total cost of freight service between rail and road on the y-axis, and thereby it is directly related to the expected incentive effect of State aid on the modal shift. For Austria, Germany, Italy, Romania and Slovakia, the average eligible costs are lower than the additional cost of rail transport compared to road transport: State aid compensating the half of the external costs differential between the two modes of transport would not be enough to make rail freight services competitive vis-à-vis road freight services. For the Czech Republic, Lithuania, Poland and Spain instead, the dots in the scatter plot are located on (or very close to) the red diagonal line: The difference in total costs between rail and road is approximately equal to the half of the differential of external costs between the two modes of transport (e.g., 1.75 ct/tkm for Czech Republic, 0.6 ct/tkm for Lithuania, 0.4 ct/tkm for Poland and 0.5 EUR -cent/tkm for Spain). State aid for such costs could bridge the cost gap between the two types of transport.

The external costs considered above are an average value per country. Within a country, external costs are likely to differ across routes depending on geographic conditions, available infrastructure, population density and other factors. For this reason, the right panel of Figure 42 also includes the Rotterdam – Genova route as a specific example. For this route, we used the external costs calculator designed by EcoTransIT[425], which allows the estimation of greenhouse gas emissions for specific origin-destination pairs for different modes of transports (e.g. road, train, IWW). It turns out that the amount of Well-to-Wheel[426] (WTW) GHG emissions for road freight services is nine times larger than for rail freight transport for the Rotterdam – Genova[427] route (GHG emission are 0.99 tonnes for rail and 8.6 tonnes for road transport). The difference in external costs also has the same magnitude, as estimated by the UIC external cost calculator:[428] The total "air pollution" external costs for this specific route are 208 EUR for road freight transport vs 25 EUR for rail freight transport. Given that the comparison is done between a truck of 26-40 t over 1,164 km and a train of 1,000 t over 1,219 km, the external

[425] https://www.ecotransit.org/en/emissioncalculator/.

[426] A "Well-to-Wheel" measure of greenhouse gas emissions includes all the emissions produced from the resource extraction to use in the vehicle (e.g., fuel production, processing, distribution, and use).

[427] The comparison is between a 26-40t EURO 5 truck with diesel engine and load factor of 60% and a 1000 tonnes electrified train of class EU UIC 2 and load factor equal to 60%.

[428] http://ecocalc-test.ecotransit.org/tool.php. The climate change cost is calculated with 25.0 €/tCO. All external costs refer to 2008 and are also expressed in the price level of 2008.

costs are respectively 0.44 ct/tkm and 0.002 ct/tkm. By assuming the differential of total costs of rail/road freight services for Germany (the country representing the largest section of this route), the Rotterdam – Genova route is shown as a cross at points (0.22;2.07) in the right panel of Figure 42 (in the left panel, the y-axis represents the total costs of rail, equal to 4.6 ct/tkm). Thus, State aid compensating the eligible costs for this specific route would not be sufficient to bridge the gap in total costs between road and rail freight transport services. To do so it would need to be about nine times higher.[429]

The replies to the public consultation indicate that 50% threshold for external costs is too low, too. To make rail freight transport competitive and encourage a modal shift from road to rail, respondents suggested that the differential in external costs should be supported at 100%. They agreed that only complete equalisation of costs would sufficiently incentivise stakeholders to develop rail freight or intermodal services.

The research conducted by the Consortium does not allow us to suggest a specific new level for this threshold. Instead, it shows that the different countries have different needs. As illustrated in Figure 42, the differential of external costs between road and rail for the Czech Republic, Lithuania, Poland and Spain are effectively addressed by the current 50% threshold, thought the same cannot be said for the other countries. A new approach could be designed to directly and fully bridge the differential of external costs between road and rail transport, rather than using a "one-size-fits-all" threshold, which will not effectively address the diversity of market conditions. An example of this approach is the State aid decision SA.39883[430], where the EC approved an aid intensity of 60% based on the differential of external costs between accompanied rail freight transport and road freight transport, on the basis of estimations calculated by the Romanian authorities.[431]

CONCLUSIONS:

Stakeholders indicated that State aid up to 30% of total rail freight costs is too low to incentivise undertakings to a modal shift from road to railway transport in many cases. An example mentioned in the replies is that track access charges alone represent 30% of the total costs of railway transport in some countries. Higher thresholds like 50% and 60% could incentivise stakeholders to develop rail freight or intermodal services. The threshold for total cost would also need to be increased if the threshold for aid for the reduction of external costs is to be increased significantly. If the threshold of total costs is not updated accordingly, it would hamper the effectiveness of the aid for the reduction of external costs.

For the majority of countries, State aid compensating for half of the external costs' differential between the two modes of transport would not be enough to make rail freight services competitive vis-à-vis road freight services. Conversely, in the Czech Republic, Lithuania, Poland and Spain, the difference in total costs between rail and road is approximately equal to half of the differential of external costs between the two modes of transport. State aid covering eligible costs could thus bridge the cost gap between the two types of transport in these countries.

4.8.3 Aid to reduce the cost of access to rail infrastructure

Within the State aid database described in Section 1.4.2, the Consortium identified 15 schemes which offered aid to reduce the cost of access to rail infrastructure (for example through offering track access charge reductions). This included 4 COVID support schemes which introduced or altered cost of access charges in response to the COVID-19 pandemic.

Publicly available ex-post analysis was available for just 1 of the 11 schemes which did not concern the COVID-19 pandemic. In 2015, Italy introduced a rail freight transport scheme (SA.45482) which compensated rail freight operators for both external costs,

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[429] Nine time higher can be calculated from the point coordinates on the figure: 2.07/0.22.
[430] SA. 39883.(2014/N). Romania State aid scheme for Ro-La combined transport. Available at: https://ec.europa.eu/competition/state_aid/cases/255363/255363_1660684_121_2.pdf.
[431] Within the State aid database, we identified 34 schemes which granted operating aid under the provisions for reducing external costs (34/48, 70.83%).

and the costs of access to infrastructure in southern Italy, and in 2016 extended this scheme to the entire State. In the 2019 renewal of the scheme (SA.55025), the Italian authorities noted that the proportion of freight transport by rail in Italy increased very slightly (0.4%) between 2014-2017 whereas in the EU 28 it decreased by 1.1% over the same time period which led the Commission to conclude that the scheme had been successful in supporting the rail freight industry particularly as the largest increase in Italy was seen in 2015 and 2016, the first two years the scheme was introduced.

Of the 4 schemes which were introduced or extended aid to reduce the cost of access to rail infrastructure in response to the COVID-19 pandemic, two Member States amended existing State aid support schemes and two other introduced new schemes.[432]

Ex-post evaluation was publicly available for one of these schemes. In 2011 under SA.33993, *'Aid for the provision of certain combined transport services by rail in Austria'.* Austria introduced operating aid to three categories of intermodal transport: i) single wagonload traffic; ii) unaccompanied intermodal transport; and iii) accompanied intermodal transport. Operating aid was awarded in the form of a subsidy which was designed to compensate for both the costs of access to rail infrastructure and external costs. The scheme was initially successful in causing a modal shift with the Austrian authorities finding that the scheme led to a 2.8% increase of transport volume in tkm in the three supported categories of intermodal transport during 2013-2015. The scheme also appears to have been effective from a cost perspective with €1 under the scheme avoiding an average of €3.41 of external costs during 2013-2015 and €3.39 during 2016.[433] In 2020 in response to the COVID-19 pandemic, Austria extended the scheme to a full waiver of access charges (SA.57371)[434] to the three supported modes of transport and extended the scope of this provision to the other types of rail freight. This alternation was extended twice in 2021 (SA.60655 and SA.63825).

In 2018, under SA.51956 Germany introduced an aid scheme for the promotion of rail freight transport, under which it covered 40-45% of track access charges for rail freight undertakings. With the onset of the COVID-19 pandemic this level was increased to 98% from March 2020 until May 2021 (SA.63635 and SA.62763).

The two remaining schemes, Sweden (SA.100464) and Italy (SA.59376, SA.62762, SA.63652) also reduced track access charges in response to the COVID-19 pandemic. As both measures are relatively new, no publicly available '*ex-post'* analysis is available.

CONCLUSIONS:

The Consortium identified 15 State aid schemes which offered aid to reduce the cost of access to rail. Publicly available ex-post analysis was available for two schemes and it was positive: they led to an increase in rail freight volume.

4.8.4 Start-up aid for new intermodal transport services

State aid for start-up companies offering new freight intermodal transport services has the potential to establish new, less polluting transport type options. Several Member States have previously implemented State aid schemes for new services related to freight intermodal transport with a 3-year duration.[435] This Section presents the summary of the effects of such schemes based on the survey conducted with the relevant granting authorities and/or beneficiaries.

[432432] These are: Austria (SA.57371, SA.60655, SA.63825), Germany (SA.62763, SA.63635), Sweden (SA.100464) and Italy (SA.59376, SA.62762, SA.63652).

[433] See recital 20 of 'SA.48390 Austria - Prolongation of aid scheme for transport of goods by rail in certain combined transport services for 2018-2022'. Available at https://ec.europa.eu/competition/state_aid/cases/269839/269839_1971628_105_5.pdf.

[434] Note that aid to reduce external costs still exists for the original 3 modes of transport.

[435] For example, State aid scheme N 640/08 was offered in Germany by the Saxon State Ministry of Economic Affairs, Employment and Transport from 2009 to 2015. Measure 3 of that scheme offered start-up aid for new combined transport services with a maximum three-years eligibility period. Aid was aimed to compensate financial risk involved in starting a new transport service. Another scheme, N449/2008, was offered

We received feedback from the German granting authority regarding the scheme N 640/2008, as well as from the Directorate-General Care of the Territory and the Environment of the Italian Emilia-Romagna region regarding SA.54990 (2019/N), and from the Italian intermodal operator Interporto Campano SpA regarding N449/2008.

Table 27 below presents our overall assessment of the effectiveness of the scheme, the appropriateness of its 3-year duration and the incentive structure for the three above-mentioned cases.

Table 27: Assessment of incentive schemes to start-ups

Scheme	N 640/2008, Measure 3 (DE)	N449/2008 SA.26505 (IT)	SA.54990 (2019/N) (IT)
Beneficiaries	Two potential beneficiaries withdrew their State aid request before it was approved.	Interporto Campano SpA	13 beneficiaries (logistics undertakings and multimodal transport operators)
Total amount of subsidies	No funds were granted.	397.000 €	Beneficiaries obtained 39,5 % of the total budget available in 2020, and 67.9 % of the total budget available in 2021. Year 2022 is still to be assessed. Low contributions in 2020 is due to low transport volumes during the COVID-19 pandemic.
Description of the service(s)	n/a	Railway service connecting the intermodal terminal of the Port of Naples to the intermodal terminal of the Nola freight village.	27 services (10 new, and 17 enhanced) Intermodal rail/road (63%), Intermodal SSS/road (19%), rail (7%), logistics services (4%)
Beneficiaries viable after 3 years?	n/a	No. Service was stopped after one year. This was driven by factors unrelated to the design of aid: inefficiencies and high handling costs in the intermodal terminal of the port of Naples.	3-year period is not yet finished.
Duration of 3 years appropriate?	n/a	n/a	Proposal is to extend the scheme to 5 years. The aid would still be provided in 3 tranches (paid annually) but over a total period of 5 years.
Scheme structure appropriate?	Intensity too low, especially for small and	The scheme was stopped because costs were higher than	The proposal is to make the structure more flexbile by allowing the

in Italy for three years from 2009 to 2012. It subsidised combined road-rail transport of containers from the port of Naples to the freight village Nola. The third scheme, SA.54990 (2019/N), has been offered in Italy between 2020 and 2022 by the Emilia-Romagna region. It subsidises logistics undertakings and multimodal transport operators by compensating the difference in external costs of road transport. Further schemes were offered by France and the Netherlands.

	medium-sized companies. Competition from other EU funding programmes (e.g. Marco Polo II) had a limiting effect on the use of this funding opportunity.	estimated in the State aid application. Reasons are: difficulties in picking up container from the port terminal; high handling costs from port of Naples to Napoli Traccia railway station; low capacity of the port railway terminal, which has only one track to operate an entire train.	beneficiaries to change the origin or destination of the services (keeping the same length of route), and/or freight type. This would allow the beneficiaries to adapt to changes in the market. The intensity of the aid could be increased to reflect the increase in costs due to the current geopolitical situation.

Source: The Consortium based on the information collected from the Saxon ministry of transport, Directorate-General Care of the Territory and the Environment of Emilia - Romagna region, and from the intermodal operator Interporto Campano SpA.

Summing up, the start-up scheme in Germany was not used and has not triggered any new services in intermodal transport. The scheme appears to have been insufficiently attractive due to low aid intensity and the availability of other aid opportunities. Also, in the case of the scheme N449/2008, the lack of success of the start-up aid is due to the market situation, not to the structure of the scheme itself as highlighted by the beneficiary in the stakeholder consultation. The intermodal transport service was not profitable because of high costs caused by inefficiencies and capacity constraints in the port of Naples and its railway terminal. Avoiding such a scheme failure in the future therefore requires firstly, a reasonable ex-ante prediction of costs in the State aid application, secondly an in-depth understanding of potential problems within the infrastructure (including capacity of the terminal and number of tracks to operate incoming trains) and lastly, ability within the scheme to adjust aid intensity during the relevant period. Another useful instance where adjustments in aid intensity can be helpful are the first years of operations for a start-up undertaking.

Among the three analysed schemes, only the SA.54990 scheme proved to be effective. However, in this case, the spreading of the COVID-19 pandemic seriously affected the operations of the beneficiaries during the first year of the program, which led to the provision of lower amounts of subsidies than were originally foreseen. For this reason, the feedback from the Directorate-General Care of the Territory and the Environment of the Emilia-Romagna region stressed the need to make the aid scheme more flexible, both in terms of duration and in terms of the characteristics of the services that can be supported.

CONCLUSIONS:

Several Member States have offered State aid schemes for start-ups in innovative intermodal transport services. The Saxon Ministry explained that their scheme was never used by any beneficiary due to reasons unrelated to the design of the scheme. Scheme N449/2008 was stopped after one year due to higher costs than expected, which were caused by market failures. Finally, scheme SA.54990 has been effectively implemented, although the implementation was affected by the COVID-19 pandemic. This is persuasive evidence that more flexible aid schemes, in terms of duration and types of services, could be effective in the future.

4.9 Conclusions

The objective of this study is to provide facts and figures to underpin the analysis of different policy options for the revision of the RG. Furthermore, we also provide first conclusions from the cost, revenues and profitability figures of rail freight and intermodal transport, which can be relevant for State aid policy.

First, we identified multiple market segments where rail freight operations are not profitable for the RU. In such segments, the market does not deliver incentives to enter and/or expand supply of services:

(i) Countries: on average, rail freight in Austria, Germany, Romania, Slovakia, Sweden, and Switzerland operates with losses (still, RU offering specific, profitable services in those countries may operate without losses). Operating at near near-zero margins or breaking even: Czech Republic, Lithuania, and Spain;
(ii) Incumbents appear on average unprofitable, in contrast to non-incumbents;
(iii) Single-wagon transport is unprofitable due to higher costs than block trains and intermodal transport, which are profitable;
(iv) Freight categories yielding relatively low revenues are food and coal and lignite (although rail appears competitive versus road for coal and lignite);
(v) National rail freight transport is on average unprofitable, in contrast to international transport, which is likely driven by a longer distance and thus reduced cost of international routes;
(vi) Accompanied intermodal transport is not profitable, in contrast to unaccompanied intermodal transport.

This is partially confirmed by price elasticity estimates, which tend to be low for most bulk goods and block trains, but tend to be higher for single-wagon and intermodal transport and for non-bulk goods. State aid in these latter segments could prove helpful to increase transport volume on rail.

Second, short-distance trains can be expected to need State support to be profitable, since the length of the rail leg is a key factor for competitiveness of rail vis-à-vis road. As a minimum distance to break-even in rail freight, most sources point to a range between 100 and 600km. However, high volumes and shuttle frequencies can potentially make even short distances profitable. Some types of freight are also conducive to shorter competitive distances, for example certain chemical products need to be transported by trains. The profitability of such rail transport does not need to be supported by State aid.

Third, within the three intermodal transport modes (rail/road, IWW/road, SSS/road), the IWW/road transport appears the least profitable to the shipper due to the highest transshipment cost. Shipments with a short main rail leg relative to the initial/final road legs tend to be less profitable. Likewise, low volume of freight in IWW/road and SSS/road transport modes deprives them of profitability. Such types of transport are likely to need State support to be profitable.

Fourth, competitiveness of rail over longer distances can be stifled by inefficiencies caused by national borders. On some borders in the EU, cross-border traffic is characterised by additional costs due to technical interoperability, additional labour cost and unharmonised regulations and standards. Reducing the cost of border-crossing would thus improve profitability of cross-border rail transport and allow exploiting cost efficiencies due to longer routes.

Fifth, the threshold for State aid that can be granted without notification up to 30% of total costs is too low to incentivise undertakings to a modal shift from road to railway transport. Stakeholders in the consultation suggested threshold levels of 50% - 60% or even 100% as a more appropriate level.

Sixth, the differential of external costs between road and rail for the Czech Republic, Lithuania, Poland and Spain is already effectively addressed by the current 50% threshold for State aid to reduce external costs, while the same is not true for the other MS. Since different countries appear to have different needs, a new approach could be designed to directly and fully bridge the differential of external costs between road and rail transport, rather than fixing a "one-size-fits-all" threshold.

In light of the significant negative external effects generated by road transport and favourable conditions to road transport in many MS, a policy option is to tax road transport for its external costs. Such a policy would make rail, which has a significantly lower external costs, more competitive vis-à-vis road and would incentivise shippers and freight logistics service providers to shift transport volumes from road to rail.

Finally, several Member States have offered State aid schemes for start-ups in innovative intermodal transport services. Two schemes evaluated retrospectively in this study proved not effective. The third scheme was implemented successfully, but the available budget was not exhausted. More flexibility in terms of duration and type of services would help to improve the scheme effectiveness, which was reduced in the COVID-19 pandemic.

It may also be useful to consider what types of operating State aid are likely to be most efficient in shifting transport volumes from road to rail. Granting authorities could specifically target routes and segments that show greatest potential for a modal shift. For instance, reducing costs of an intermodal transport chain could incentivise a substantial number of customers to move from road to intermodal transport. Furthermore, most demand for transport is on short routes where trucks are predominant. Therefore, State aid allowing to reduce the distance at which rail starts outcompeting road would likely be effective in fostering a mode change. Thus, State aid to start-up RU offering short-distance shuttle services appear a plausible way to boost the attractiveness of rail over road.

Single-wagon transport entails potential for shifting transport volumes from road to rail, especially in situations where intermodal transport is not a viable alternative. Notwithstanding this potential, a significant amount of State aid is likely required to make it competitive in most scenarios. Austrian rail exemplifies that subsidies can be effective in maintaining sizeable single-wagon operations. Complementarily, governments could attempt to foster investment in infrastructure or rolling stock to improve conditions for RU that conduct single-wagon transport.

5. Conclusions on the design of State aid for rail freight

This section collates all conclusions about the design of State aid for rail freight from this study. We start with the review of evidence of partial pass-through (Section 5.1), then discuss the effectiveness and efficiency of State aid for the consumers vs freight undertakings (Section 5.2) and we conclude with suggestions where State aid could make a difference and a collection of examples of successful State aid design (Section 5.3).

5.1 State aid impact on final prices

In this Section we present descriptive evidence suggesting a partial pass-through of State aid, unless it is paid directly to the end user and thereby respond to the study question 29 (see Annex 2). Similarly, descriptive evidence indicates that increases in road haulage costs to encourage modal shifting are only passed to end users by larger hauliers with bargaining power. Econometric evidence demonstrating that past state support has been reflected in the price demanded from shippers using intermodal transport or inland waterways is not available.

The methodology of the section on pass-through was to assemble as much academic empirical research as possible that would either apply directly to the question or, given the scarcity of studies directly focused on pass through for intermodal rail support, for other related transport aids or taxes.

A number of econometric studies consider resident subsidies for airfares and maritime passenger transport between the mainland of EU Member States and their islands. These studies show that even if a subsidy is passed through in accounting terms to residents, in economic terms only partial pass-through occurs as the price excluding the subsidy increases. However, these studies are based on relatively small samples, and it is not clear whether they fully control for cost differences between routes.

Given the limited empirical evidence, a summary of theoretical results on pass-through in simplified settings is provided in Annex 8. The theoretical literature shows that the full and exact pass-through of subsidies to end users will only happen in a rare set of circumstances and not only can pass through be less than the volume of aid, but it can also be possible for end user prices to fall by more than the value of a subsidy. In general, the rate of pass-through depends on how competition is modelled, the precise shape of the demand and cost/supply curves, and the form that a subsidy takes. Pass through is not the sole objective of state aid in the rail supports examined, with key objectives including to ensure that a service is made available in the first place, in addition, as with terminal investments, to ensure that the service exists and becomes cheaper to the end user.

Descriptive evidence relating to rail freight subsidies: Trafikverket (2018) views a pass-through not only when there is an immediate reduction in prices, but also if a constant or increasing price, following a cost increase, is stopped, or limited by quality improvement (e.g., investment in punctuality). In evaluating a scheme of environmental compensation to RU in Sweden, Trafikverket (2018) notes that pass-through mechanisms varied by whether administrative costs are deducted when making direct payments to buyers, and that direct payments could take the form of credit notes issued after buyers have paid the transport provider.

STA (2018) finds that only in a few individual cases do beneficiaries report a reflection of the subsidy in buyers' prices that is incompatible with the overall purpose of the scheme. However, the ability to pass-through the aid as lower prices is made more challenging by the scheme involving a fixed subsidy budget compared to subsidies dispersed to rail firms in arrears on a 6 monthly basis based on observed market shares. Hence, the subsidy rate per tonne-kilometre incorporates a degree of uncertainty. In State aid decision SA.60383, regarding the continuation of this scheme, the payment of the subsidy to RU will occur every 3 months, potentially reducing this uncertainty.

In State aid decision SA.55025, on the continuation of an Italian rail freight subsidy scheme, Italian authorities report that in the scheme's previous iteration price increases were avoided and some instances discounts were provided. The decision cites one RU reporting a price increase of below 1%, 5 RU reporting no price increases despite cost increases, 2 RU having average charge reductions of 2-3% and 1 RU reporting an average charge reduction of over 15%.

More generally, EC (2016), in an ex-post evaluation of the Combined Transport Directive 92/106/EEC and, in particular, with reference to reductions in taxes for road vehicles engaged in intermodal transport states: "currently the beneficiaries of the support are road operators based on distances on rail transport; such an approach does not necessarily translate into cheaper prices to users and thus does not always support the decision to use CT instead of long-distance road transport." Furthermore, KombiConsult et al (2017) notes that state supports may be captured by intermediaries meaning that there is anecdotal evidence of some UK train operators increasing their prices to customers to secure government intermodal CT incentives.

Monios (2015) when investigating the use of intermodal transport by UK supermarkets reports evidence consistent with a partial pass-through of subsidies from the Modal Shift Revenue Support scheme to retailers. One retailer thinks that transport firms provide intermodal quotes that are only 'slightly cheaper than road' rather than quotes that reflect the actual costs of providing the service, which are non-transparent. However, Monios (2015) recognises that large retailers can use their bargaining power to drive down handling charges and that rail operators feel that they cannot lower their prices further.

To ensure the pass-through of State aid, schemes can provide support directly to the shipper (or logistics service provider, depending on who decides which mode of transport is used). Woodburn (2007) explains that this was the structure of Freight Facilities Grants (and prior to this Section 8 funding under the Railways Act 1974) in the UK. These grants support shippers with the capital costs of new or replacement assets which retain or attract freight on railways, i.e., company-specific infrastructure at their sites or rolling stock. Similarly, decision SA.34985, concerning Austrian guidelines on the construction of private railway connections, involves a scheme which only allows payments to businesses that are shipping cargo, with railway Infrastructure managers and RU being ineligible.

Pass-through of road tax and fuel costs by road hauliers: An alternative fiscal intervention to increase in intermodal freight transport is to increase the costs of road transport. Doll et al. (2017) interview stakeholders about the German Lkw-Maut system of road tolls introduced in 2005 and compare this to heavy goods vehicle (HGV) tolls in Spain. The interviews suggest that in Germany large road haulage companies were able to pass on the increased cost of tolls for loaded trips, and sometimes the costs for empty trips. However, in Spain, due to a greater proportion of small and very small haulage firms, it was thought that the pass-through of tolls was likely to be less frequent. Similarly, when considering the impact of the UK's HGV Road user charge for using the UK as a land bridge to Europe, Vega and Evers (2016) report that road haulage and freight forwarder interviewees thought that there would be little room for them to pass on the increase in costs to exporting firms. Again, Vega and Evers (2016) emphasise the fragmented nature of the Irish road haulage sector which means hauliers have limited bargaining power.

Turning to Switzerland, the Federal Office for Spatial Development (ARE) (2015) finds that, depending on company, between 40% and 100% of the distance-related Heavy Vehicle Fee (for vehicles weighing more than 3.5 tonnes) is passed on to shippers.

Also, Rigot-Muller (2018) suggests one reason why the HGV "écotaxe" in France failed to be implemented is the way the tax was intended to be passed through to end users. Rather than relying on companies' individual price negotiations for the pass-through, there was a mandatory surcharging system where hauliers could increase invoiced amounts by an ad valorem ratio dependent on where the transport occurred. The ratio varied by region, with transport between regions having a standardised rate. It is also suggested that this invoicing approach created a distortion between specialist haulage companies and shippers who operated their own vehicle fleets.

Turning to the pass-through of fuel price increases by road haulage firms, McKinnon (2007) cites UK evidence from Aleszewicz (2005) that in a sample of 29 hauliers on average only 27% of fuel price increases in the prior year had been passed through to haulage prices. However, there were wide variations across hauliers, with 12 firms recovering less than 5% of cost increases, but 9 recovering at least 50%. Only a quarter of firms had contracts where fuel cost increases above an agreed level were automatically compensated, with 75% of firms reporting that compensation for fuel price increases usually or always involved negotiation.

McKinnon (2007) also cites evidence from the Burns Inquiry (2005) which concludes that around 60% of UK hauliers were able to "substantially recover fuel costs" in 2005. However, significant variations by haulier size are again noted with 53% of hauliers with 1-5 trucks being able to substantially recover fuel costs compared to 77% for those with 6-25 trucks, and 79% for those with at least 26 trucks. This gap between small and larger hauliers has grown since 2000 when there was essentially no variation by haulier size.

Accounting mechanisms to support pass-through: While not addressing the question of whether prices in absence of the subsidy change, State aid decisions indicate legal and administrative efforts to support subsidies reaching end users. Tsamboulas et al. (2015) note that for the Italian Ferrobonus scheme, if the aid recipient was not the end transport user, the aid recipient was required to provide a discount to their customers equal to at least 40% of the contributions received. In Austria, decision SA.33993 notes that subsidy contracts will be published on the Federal Ministry for Transport, Innovation and Technology's website so that business partners of beneficiaries can include subsidy information in their business negotiations. Also, final customers will be made aware of the aid via their invoices. In Sweden, SA.60383 notes a similar transparency approach with information on aid amounts being publicly accessible to shippers. In Belgium, decisions SA.36207 and SA.42388, concerning intermodal transport of containers on waterways in the Brussels region, notes that the Brussels Port Authority disperses the aid to shippers via a deduction of EUR 17.5 per intermodal transport unit. This deduction is explicitly marked on the invoices, the government can use random checks to check the subsidy has been passed on, and, if non-compliance is detected, the government can reclaim all the aid and levy a fine equal to 10% of wrongly received subsidies.

Arup (2020) describes how in December 2018 the EC approved a German scheme providing EUR 350m per annum to compensate rail freight operators for 40-45% of track access charges (TAC). Rail freight operators benefiting from this scheme must inform customers of the aid and pass the subsidy on via lower prices to end users.

Econometric evidence from passenger transport: Econometric studies highlight that having an 'accounting mechanism' requiring a subsidy to be accounted for in the final price paid by end users is insufficient to ensure full pass-through of the subsidy: the application of a subsidy can be accompanied by the pre-subsidy price increasing. The evidence focuses on ad valorem (percentage) subsidies for island residents and a partial pass-through of the subsidy to residents implies that non-resident passengers experience a price increase following the introduction of a subsidy. Jimenez et al. (2018) explain that the price increase results from ad valorem subsidies increasing total demand and reducing residents' price elasticity of demand.

Jimenez et al. (2018) consider the impact of resident subsidies on the price per kilometre on 40 maritime routes in 13 European countries in 2016. Using two-stage least squares (2SLS) and kernel matching these authors conclude that routes receiving subsidies have pre-subsidy prices 37-43% higher than routes that do not receive subsidies.

Calzada and Fageda (2012) consider Spanish airfare data between 2001 and 2009 on 86 domestic routes using a 3-equation model (demanded quantity, price, and flight frequency) with instrumental variables where relevant. They find that round trip flights are

EUR 65 higher on routes where resident discounts exist than on routes without discounts. The authors note that the observed price increase associated with resident discounts may be being moderated by the fact that airport fees on islands are lower than at mainland airports.

Fageda et al. (2012) consider the pricing of airfares to Gran Canaria where the Spanish government gives a 50% ad valorem discount to fares for residents. Using data from 2009 and 2010 and 2SLS, Fageda et al. (2012) show that flights to the Spanish mainland (i.e., those subject to subsidies) had pre-subsidy prices EUR 139 to EUR 149 above flights to non-Spanish destinations.

However, Fageda et al. (2016), using panel data from Spanish domestic routes between 2003 and 2013 and a difference-in-difference methodology, fail to find statistically significant increases in the price differences between subsidised and unsubsidised routes when the level of the ad valorem subsidy rose from 33% in 2003 to 50% by 2007. However, in a theoretical paper, Socorro and Betancor (2020) note that an increase in subsidy can lead to a greater pass-through if the subsidy's size and resident demand are sufficient for a previously monopoly service to attract a second competing airline. Socorro and Betancor (2016) suggest that such a situation may have occurred between October 2017 and June 2019 when the ad valorem resident subsidy for the Canary Islands mentioned above was increased to 75% after 2017 and led to a second airline temporarily entering.

Fageda et al. (2017) extend the analysis to include data from France, Greece, Italy, and Portugal, although, the bulk of the data remains from Spain. Using 2SLS and kernel matching estimators, they conclude that the pre-subsidy price is higher on routes where only residents receive a subsidy, but where all passengers receive the subsidy no statistically significant increase in the pre-subsidy price was found.

Other evidence relating to public transport: Bly and Oldfield (1986) look at simple correlations between subsidy levels and changes in public transport fares using data from multiple countries. Based on national aggregate statistics from 16 countries for all, or part, of 1965 to 1982, a subsidy increase covering an extra 1% of operating costs was associated with a 0.58% decrease in fares in real terms. Using data from 117 individual cities in 11 countries, mostly for the period 1970-82, a subsidy increase of the same size was associated with a decrease in fares in real terms of 0.94%.

A situation where one would expect a high, and possibly full, pass-through of transport subsidies is when a public transport service in an urban area is made completely free. Storchmann (2003) discusses the fee free public transport offered in the German town of Templin and the Belgian town of Hasselt, while Straub and Jaros (2019) provide a more general discussion of free public transport. As the price is set to zero all of the subsidy is being used to cover the costs of service provision. If the service is run efficiently by a non-profit entity, or there is competition between profit-making enterprises so that firms only achieve the minimum return required to satisfy their investors, there would be full pass-through.

CONCLUSIONS:

The limited descriptive evidence found, all of which is reported here, suggests at least a partial pass-through of state aid for intermodal purposes, in circumstances where aid is not paid directly to the end user.

Similarly, the descriptive evidence described above indicates that increases in road haulage costs, which can be viewed as the inverse of state support, to encourage modal shifting are only passed to end users by larger hauliers with bargaining power. If this descriptive evidence is correct, the effect of the tax is blunted by the absence of pass through from smaller hauliers.

The setting in place of accounting requirements for full or proportionate pass through can at least tentatively be seen as an imperfect mechanism to guarantee pass through of support, as the application of a subsidy can be accompanied by an increase in the pre-subsidy price. The evidence from studies is mixed on this point, and may depend on whether the support leads to the entry of a second supplier.

Econometric evidence demonstrating that past State support has been reflected in the price demanded from shippers using intermodal transport or inland waterways is not available.

5.2 Efficiency of State aid to consumers vs undertakings

Demand-side State aid is directed to users of railway services (clients, shippers, logistics service providers). In other words, it supports end-users making the choice between all transport modes for freight transport. In contrast, supply-side aids are directed to railway undertakings, which are the one offering rail freight transport services.

In this Section, we assess the differences in the efficiency of demand-side and supply-side State aid based on available academic literature, industry reports and the responses to the stakeholder survey. Thereby we answer the study question 16 (see Annex 2).

In the existing sources, there is limited direct evidence of the pass-on of subsidies to freight transport prices. Most of the time, evaluations focus on the effect on the modal shift generated by State aid. However, we can interpret modal shift effect as an indirect evidence of price effects. Indeed, State aid that leads to a modal shift from road to rail means that shippers or logistics service providers consider subsided rail freight services to become more competitive compared to road-only transport.

On the demand-side State aid, the Italian Ferrobonus State aid[436] was given to users of railway services to optimise the use of intermodal rail freight transport and enforce a modal shift from road to rail. Another State aid scheme for the demand-side was the Italian Eco-bonus[437] that aimed to implement a modal shift from road to short-sea transport.

On the supply-side State aid, the Austrian Aid for the provision of certain intermodal transport services by rail[438] and Aid for Innovative Combined Transport[439] were given to RU to compensate additional costs faced by rail and achieve a modal shift from road to rail. In addition, the German TraFöG[440] supports RU through a proportionate financing of track access charges.

The following table summarises the evaluation of State aid effects in those schemes. Note that the effects are observed during the period covered by the evaluation reports, while long-term effects are not included. Moreover, the reported measures of the modal shift volume and efficiency should be read as an indication of effects rather than hard evidence, since none of the evaluation reports used methods allowing for the identification of causal effects.

Table 28: Summary of State aid effects

Scheme	Total amount (€)	Modal shift volume	Efficiency Indicator	Comments
Ferrobonus (2010-2011)	23,311,447.09	3,821,638.47 train-km (+17.3%)	1.05€ per train-km 6.1€ per additional train-km	
Ecobonus (2007-2010)	67,000,000	87,564 semi-trailers (+12.1%)	765 euros per shifted semi-trailer	Only about international routes between Italy and Spain (30% of the aid)

[436] Offered in Italy from 2010 to 2011 and extended in 2016 for 3 more years. This aid took the form of a subsidy set at 2 euros per train-kilometre of intermodal or transshipment services.
[437] Offered in Italy from 2007 to 2009. The form of the aid was a non-reimbursable grant corresponding to the existing difference between the external costs generated by maritime and road transport. This difference is 133.21 euros for a 100-km stretch.
[438] Offered in Austria from 2013 to 2017 and has been prolonged for the 2018-2022 period. The aid is granted in the form of a non-repayable direct grant.
[439] Offered several times (1999-2002, 2003-2008, 2009-2014, 2015-2020, 2021-2025) in Austria.
[440] "Trassenpreisförderung im Güterverkehr" offered since 2018 by the German Federal Ministry of Transport and Digital Infrastructure.

Aid for rail transport in certain combined transport services (2013-2017)		+2.8% ton-km	1€ of aid for 3.14€ of external costs saved
Aid for Innovative combined transport (2009-2014)	15,117,941	58.121 bn tkm (+36%)	0.26€ for 1000 t-km
Aid for Innovative combined transport (2015-2020)	10,760,000	47.74 bn tkm (+24%)	0.23€ for 1000 t-km
TraFöG (2018-today)	Between 175,000,00 and 350,000,000		50%-100% pass-on on final prices

Source: The Consortium based on the industry and academic literature.

All State aids are evaluated with different types of indicators that impede a direct comparison between them. In what follows, we attempt a general assessment of the effects of these schemes.

Demand-side aid evaluation

On the demand-side measures, the general feedback from the EC decisions and academic literature are that *Ferrobonus* and *Ecobonus* schemes achieved a modal shift from road to rail or short-sea transports and a positive effect on freight volumes transported by more sustainable modes of transport.

First, the EC State aid decision on *Ferrobonus* prolongation of 2016 indicates that the first edition of the *Ferrobonus* programme achieved its goals. There was an increase of rail intermodal transport by 17.3% or 3,821,638.47 train-km between 2009-2010 and 2010-2011. The aid amounts to 1.05 euros per total train-km or 6.1 euros per additional train-km.[441]

In addition, Tsamboulas et al. (2015) evaluates *Ferrobonu*s efficiency specifically on the rail Genoa-Barcelona connection. According to them, it created an estimated modal shift of 1.13% of transported tons captured from road on the specific route, with an increase of 55,838 tons/year.

According to a recent report from RAM (2019), *Ecobonus* created an increase of "Roll-on-roll-off" (RoRo[442]) traffic volumes on Italian-Spanish routes by 12.1% between 2007 and 2010, compared to pre-scheme volumes. In absolute terms, 87,564 trailers shifted from road network to short-sea routes. *Ecobonus* scheme has consistently sustained RoRo traffic demand by the same extent also after the end of the scheme, from 2011 to 2013. In absolute terms, 1.332 million tons out of the 9.409 million transported over the 2011-2013 period on Italian-Spanish RoRo routes have to be credited to the *Ecobonus*.

Supply-side aid evaluation

First, the EC State aid decision of 2017 on the *Aid for transport of goods by rail in certain combined transport services for 2018-2022* indicates that according to Austrian authorities the initial scheme has effectively helped transferring traffic from road to rail. Its implementation led to an increase of 2.8% of transport services in tonne-kilometres in the supported production forms during the period 2013-2015. According to the evaluation of the scheme commissioned by the Austrian authorities, one Euro of aid under the initial scheme helped to avoid an average of EUR 3,41 of external costs during 2013-

[441] The effective amount was 23,311,447.09 Euros. Between July 2009 and July 2010, the total intermodal rail traffic equals to 18,294,421.21 train-km, and between October 2010 and October 2011, it equals to 22,116,059.68 train-km.
[442] "Roll-on-roll-off" is a ferry transport service.

2015. In 2016, with one Euro of aid under the scheme, EUR 3,39 of external costs could be avoided.

Moreover, the reports[443] from the Austrian Ministry of Climate Action and Energy on *Aid for Innovative combined transport* indicate that the programme achieved a shift of road transport to other modes of transport of 58.12 billion tkm for 2009-2014 and of 47.74 billion tkm for 2015-2020. The transferred volumes represented approximately 24% and 36% of the total freight volumes transported via rail and inland waterway transport in the respective evaluation periods, indicating high effectiveness of the schemes.[444] In terms of scheme efficiency, this indicates EUR 0.26 per 1000 tkm for 2009-2014 and EUR 0.23 per 1000 tm for 2015-2020.

In addition to these results, a report from the Steer Davies & Gleave Ltd (2015) concludes that monetary incentives for specific rail freight operations of intermodal transport provide an example of effective, targeted support. The report gives the Italian *Ferrobonus* and *Ecobonus*, and the Austrian grants for intermodal transport as examples of incentives that have created modal shift at the national level. The authors explain that such aids have tended to be more effective than rail-only incentives, because rail is already a component of an intermodal service and the incentive can therefore operate at the margin, encouraging shippers to extend the length of the rail journey rather than switch mode for the entire journey. Moreover, they highlight that infrastructure investment that supports intermodal transport is necessary, as it is rare for freight transport operations to rely exclusively on rail; therefore, improved facilities enable shippers to utilize the full potential of rail transport, while continuing to benefit from other modes (e.g. road). Enhancing transshipment facilities and terminal capacities for handling containers are some specific examples of infrastructure likely to increase the length of freight operations undertaken by the rail leg of the intermodal transport chain. The study also points to cost considerations in cross-border freight transport. Shippers are found to be less sensitive to costs in the case of longer distances, due to decreasing unit (per tkm) costs. Such freight journeys typically involve a cross-border element, hence ensuring technical standardisation and minimum regulatory barriers between different MS is of importance in improving the competitiveness of rail. Targeted investment schemes in ports and related intermodal facilities could help in achieving a modal shift to intermodality. For instance, ports (both seaports and inland ports) are key points of modal transfer and 90% of Europe's international trade is handled at these locations.

One reply to the stakeholder survey[445] indicated that subsidies to RU for track access charges in Germany since 2018 were passed on to final customers to a degree from 50% to 100%, depending on the market segment. The pass-on percentage is likely to be higher in the segments where the competition is stronger like block train and intermodal transport, but lower for the less competitive single-wagon segment. Indeed, for example, competition in the block train sector works via tenders meaning that all RU will pass-on subsidies of track access charges to their customers in order to win tenders.

CONCLUSIONS:

No comparable evidence on pass-on of supply-side or demand-side subsidies on final prices was found. Consequently, it is difficult to conclude whether one type of schemes is more efficient than the other.

[443] 2009-2014: https://www.bmk.gv.at/themen/innovation/publikationen/evaluierungen/ikv.html
2015-2020: https://www.bmk.gv.at/themen/innovation/publikationen/evaluierungen/ikv_evaluierung.html.

[444] Note these values were computed as ratios between the transferred volumes (without useful life) for the evaluation period from beneficiary-specific data, and the overall transported volumes across inland waterways and rail modes in Austria, from Eurostat. Eurostat typically covers data for undertakings offering transport services, whereas the beneficiaries supported by the scheme extend beyond railway undertakings: they include forwarding agents, port-operators and other logistic companies, in addition to shipping and railway undertakings.

[445] From the German Market regulator Bundesnetzagentur (BNetzA).

5.3 State aid design for rail freight

This section provides conclusions on the design of investment and operating State aid for rail freight, drawing from existing evidence in three key areas of the rail freight sector: infrastructure, rolling stock and operations.

5.3.1 Infrastructure and rolling stock

The European railway infrastructure is a complex system, comprising national railway networks with different types of service facilities and intermodal terminals, as well as private sidings. Each part is complementary to the other. It should thus be understood that policies aimed at supporting one level of the railway infrastructure can affect other levels as well. The following are the levels and activities where State aid is needed in infrastructure and rolling stock.

The European railway network is generally considered by the stakeholders interviewed to be congested and not suited to operate more and longer trains. This could hinder not only the goal of the modal shift, but also migration towards new technologies that could increase the productivity of rolling stock, since the investment would not bring sufficient returns. The expansion of the existing network, as well as the definition of specific routes used primarily by freight trains are possible ways to address the issue.

The available evidence suggests that the number and capacity of service facilities and intermodal terminals is not sufficient to sustain the foreseeable growth in the rail modal share and in intermodal rail transport. While there is a certain heterogeneity across countries, if one wanted to address the issue, subsidies might be needed. More specifically, intermodal terminals might also be lacking also in specific regions, which is likely due to the low returns that the investment could generate. Support to small, loss-making terminals might allow them to remain in business, and also to increase the pool of choice for shippers and the connection to the national railway network, thus reducing the negative externalities caused by road haulage and possibly allowing different parts of the networks to be used more, redirecting traffic from the congested areas.

There is also evidence of net reduction of private sidings, which is driven by the high number of dismissed sidings combined with the low number of newly built sidings. The siding itself, although important, represent only part of an interconnected rail system. As a result, while subsidies aimed at covering the funding gap are the most direct choice to support the construction of new sidings (indeed, a representative from ERFA Gleisanschlus has indicated that subsidies are essential for the development of new sidinds), they could potentially be combined with other policies (such as subsidies to single-wagon transport or the expansion of the existing railway network) to reduce the overall burden that has to be borne by a private firm which aims to build a siding. Indeed, the reduction in the number of sidings, both observed and expected, has shown that the current level of subsidies is probably not sufficient, if one wanted to incentivise the development of new private sidings.

Increased costs associated with access to rolling stock has limited the renewal rate of existing rolling stock fleets in Europe that have approached the end of their useful life. Although private investment has increased in the sector has increased over the past decade, State aid is still needed to ensure the renewal of rolling stock fleets. Additionally, access to passenger and tractive rolling stock is complex due to the lack of technical standardisation of rolling stock across Europe. This is mainly due to differences in the rail infrastructure across MS. Further, considerations could be given to additional investment in sustainable vehicles such as battery or hybrid vehicles, which could be used for pre- and post- haulage in intermodal transport, to cover the initial cost of investment.

The scarce ex-post evaluations of investment aid measures granted for rolling stock fleets which do suggest the following design features for State aid schemes. The German scheme for noise reduction (SA.34156) appears to have been successful following alterations during the COVID-19 pandemic: The scheme allowed for an extended period of up to 18 months in which freight wagon owners could accumulate mileage to ensure that they could claim and receive the appropriate amount of aid representing the average yearly freight volume. It is therefore clear that increased flexibility in schemes' *time duration* can improve their effectiveness.

The Czech scheme for IWW states that, for the majority of projects, the requested aid intensity of 49% was insufficient to cover their costs due to which beneficiaries had to self-fund the remaining 51%.[446] As a result, the intensity threshold was subsequently increased to 75% for medium-sized enterprises and 85% for small enterprises where aid intensity fell short.[447] This suggests that higher aid intensity thresholds, determined by the size of the businesses, could improve effectiveness of such schemes.

5.3.2 Operations

Following the assessment, this section provides conclusions on operating State aid which is likely to be most efficient in shifting transport volumes from road to rail. Granting authorities could specifically target routes and segments that show greatest potential for the modal shift.

First, reducing costs in an intermodal transport chain could incentivise a substantial number of customers to move from road to intermodal transport. Furthermore, most demand for transport is on short routes where trucks are predominant. Therefore, State aid which reduces the distance at which rail becomes more competitive than road would likely be effective in fostering a modal change. For instance, State aid to start-up RU offering short-distance shuttle services appears to be plausible way to boost the attractiveness of rail over road. National rail transport in small countries also needs to be supported to compete with road, since it has cannot to exploit economies of scale. Yet another example of services in need of support is IWW transport, where distance travelled is typically shorter than that travelled by rail and the tonnages transported are lower due to higher instances of the transport of empty containers.

Second, single-wagon transport brings potential for shifting transport volumes from road to rail, especially in situations where intermodal transport is not a viable alternative. Notwithstanding this potential, a significant amount of State aid is likely required to make it competitive in most scenarios. Austrian rail exemplifies that subsidies can be effective in maintaining sizeable single-wagon operations. Complementarily, governments could attempt to foster investment in infrastructure or rolling stock to improve conditions for RU that conduct single-wagon transport.

MS have provided subsidy schemes specifically for SW operations in the past. For instance, Austria has provided subsidy measures for SW transport since 2012. It is also notably recorded that the scheme has achieved lower production costs per EUR/1000 tkm for SW transport compared to unaccompanied intermodal transport in 2020. This suggests that SW transport could still be the more cost-effective train type in some areas of the EU.[448] Mandating such tangible outcomes in ex-post assessments of schemes could help in setting realistic objectives for future schemes targeted at SW transport. Moreover, schemes in other MS target specific services or segments within SW operations, covering costs for *access charges*, *provision of shunting staff*, *provision of traction vehicles for shunting purposes and external train acceptance* (see SA.58046 and SA.33417). Providing such targeted aid can improve the ease with which these schemes are implemented.

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[446] State aid No S.A. 38003 (2013/N) – Czech Republic Prolongation of the scheme N 358/2007 – State aid scheme for operators for the modernisation of inland waterway freight transport vessels, see: https://ec.europa.eu/competition/state_aid/cases/251186/251186_1535777_128_2.pdf.

[447] State Aid SA.43080 – Czech Republic State aid scheme for modernisation of inland waterway freight transport vessels, see: https://ec.europa.eu/competition/state_aid/cases/260429/260429_1837217_158_2.pdf.

[448] Production costs (EUR/1000 tkm) were lower in three out of three categories: Domestic Transport (107.9 EUR/1,000 tkm SWT, 123.2 EUR/1,000 tkm UCT) Import/Export (65.6 EUR/1,000 tkm SWT, 79.8 EUR/1,000 tkm UCT) and Transit (37.4 EUR/1,000 tkm SWT, 83.4 EUR/1,000 tkm UCT). See SA.57371.

The total operating State aid per tkm was well below 30% of the observed MS' total costs in 2019, with some exceptions like Austria and Italy. At the same time, stakeholders indicated that the 30% threshold for total costs is too low to incentivise undertakings to a modal shift from road to railway transport in many cases. For instance, track access charges alone represent 30% of the total cost of railway transport in some countries. Stakeholders therefore seek higher thresholds like 50% - 60%.

For the majority of countries and at average country levels, State aid compensating for 50% of the external costs differential between road and rail seems insufficient to make rail freight services competitive vis-à-vis road freight services. Some exceptions are Czech Republic, Lithuania, Poland and Spain. A new approach to directly and fully bridge the differential of external costs, rather than using a "one-size-fits-all" threshold, might help to incentivise market players to offer more rail freight services.

The threshold for total cost would also need to be increased if the threshold for aid for the reduction of external costs is to be increased significantly. If the threshold of total costs is not updated accordingly, it would likely be binding, thereby hampering of the beneficial effects of the increased threshold of the aid for the reduction of external costs.

Stakeholders asked for more flexibility in the design of schemes, so the scheme can be adapted when unexpected events occur. In light of this, we have reviewed a handful of failed schemes to learn from them about how the structure of the schemes could be better designed in future scheme structures. For instance, the start-up scheme provided to Interporto Campano SpA (N449/2008) failed due to high handling costs in the intermodal terminal. Avoiding such a failure in the future therefore requires firstly, a reasonable ex-ante prediction of costs in the State aid application, secondly an in-depth understanding of potential problems within the infrastructure (including capacity of the terminal and number of tracks to operate incoming trains) and lastly, ability to adjust aid intensity during the relevant period within the scheme. Another useful instance where adjustments in aid intensity can be helpful are in the first years of operations for a start-up undertaking.

Schemes should also allow RU to react to exogenous negative shocks to the market such as the COVID-19 pandemic (SA.54990). During such periods, beneficiaries suggested that it would be helpful to allow for changes in the origin or destination of the services, while keeping the length of the route and/or freight categories fixed. Further, the intensity of the aid could be increased to reflect the increase in costs due to such unforeseen events in the market.

Other operating aid schemes extended or introduced reductions to track access charges because of the COVID-19 pandemic (SA.60655, SA.62763, SA.59376).[449] Extending the level or scope of reductions to track access charges appears to be the primary way in which Member States have sought to protect the rail freight sector from the additional pressures of the COVID-19 pandemic. Finally, schemes may be designed to compensate for both the costs of access to rail infrastructure and the external costs differential to more polluting transport mode like SA.33991. This might allow making additional support available to railway undertakings.

5.3.3 Overall

Rail freight is a complex market which functions only when infrastructure, rolling stock and operations are well coordinated.

[449] State Aid SA.60655 (2020/N) – Austria COVID-19 – Amendments to the existing aid scheme for the provision of rail freight services in certain forms of production and prolongation of temporary support for rail freight and passenger transport, see: https://ec.europa.eu/competition/state_aid/cases1/20217/291037_2246250_84_2.pdf, State Aid SA.62763 (2021/N) – Germany COVID-19: Amendment of an existing aid scheme for rail freight transport, see: https://ec.europa.eu/competition/state_aid/cases1/202122/294212_2278511_39_2.pdf ; State Aid SA.59376 (2021/NN) – Italy COVID-19 - Reduction of track access charges for rail freight and commercial rail passenger services, see https://ec.europa.eu/competition/state_aid/cases1/202115/293163_2263446_46_2.pdf.

State aid for rail operations can be expected to reduce operating costs in the short term. Compared to investment State aid, operational aid has greater potential to distort competition within the rail freight segment, but it can more effectively facilitate a modal shift to rail in the short term.

Investment State aid for infrastructure and rolling stock can be expected to reduce operating costs in the long-term by supporting the use of modern and efficient technical solutions. Compared to operating State aid, such aid has less potential to distort competition within the rail freight segment, but it would likely take longer to facilitate a modal shift to rail.

Evidence is required to learn about the effectiveness and efficiency of various scheme designs, but ex-post evaluations for State aid schemes under the RG are very rare. The introduction of the requirement to evaluate schemes could facilitate the generation of such evidence, and allow for better-informed choices of scheme design in the future.

Finally, ensuring timely and smooth aid allocation can avoid administrative delays in the implementation of State support schemes. Past evidence suggests that such delays have resulted in MS under-utilising a scheme's allocated budget (SA.100031). Further, the need to apply for clearances from granting authorities to use any budget surplus in the re-introduction of schemes is often time-consuming, further delaying the implementation of the scheme.[450] Prolongation of schemes are sometimes caused by a delay in the approval of aid requests. This not only hinders the timely implementation of the scheme, but also delays payments, causing beneficiaries to self-fund and increasing their operating costs (SA.35948, SA.38115).[451]

[450] State Aid SA.100031 (2021/N) – The Czech Republic – Reintroduction of the aid scheme for upgrading and constructing combined transport terminals, see: https://ec.europa.eu/competition/state_aid/cases1/202214/SA_100031_107A6F7F-0100-CB43-BAC5-89D995B46895_41_1.pdf

[451] State aid SA.35948 (2012/N) – Czech Republic Prolongation of the interoperability scheme in railway transport (ex N 469/2008), see: https://ec.europa.eu/competition/state_aid/cases/247158/247158_1468536_73_2.pdf; State aid SA.38115 (2014/N) – Czech Republic Prolongation of the validity of the Commission decision in case N 469/2008 and SA.35948 (2012/N) (interoperability scheme in railway transport), see: https://ec.europa.eu/competition/state_aid/cases/251368/251368_1659500_231_2.pdf

Annexes

Annex 1 Literature References

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Annex 2 Definitions

Block trains refer to trains that shuttle between two sidings and transport a single commodity, most commonly bulk goods, on a large number of wagons. Block trains do not require complex logistics and allow simple point-to-point connections. They typically transport wagons for a single client.

Break-even distance is a metric to analyse train profitability. It is defined as the minimum distance at which a train becomes profitable, i.e. revenues are higher than costs.

Combined transport is the term commonly used in the industry for the transport of intermodal units. Note that this is different from the definition used in the Directive 92/106/EEC on combined transport of goods between Member States ("The Combined transport directive"). To avoid misunderstandings, this study uses the term *intermodal transport* to discuss the transport of intermodal loading units.

Freight categories refer to the type of commodities (goods) transported, e.g. products of agriculture, chemical products, metal ores and other mining and quarrying products, wood, etc. In the study we use the *Standard goods classification for transport statistics* abbreviated as NST (2007).

Intermodal transport refers to a freight transport using an intermodal loading unit such as containers, swap bodies or semi-trailers. The rail freight service is one leg in an intermodal transport chain. Further modes of transport within this transport chain could be road, short sea shipment or inland waterway. The entire intermodal transport chain is typically a *multi-client*, door-to-door service.

Intermodal organiser is an undertaking offering the entire intermodal transport chain to shippers and end-customers of transport services. It typically works together with railway undertakings and the providers of road, inland waterway and short-sea transport. In the industry, the term *intermodal operator* is often used equivalently.

Intermodal operator is the term widely used by the industry for *intermodal organiser*.

Intermodal terminals**:** service facilities for the transshipment of standardised loading units (containers, swap bodies, semi-trailers), where at least one of the modes served must be rail or inland waterway" (UIRR and UIC, 2020).

Loading units refer to the unit used to transport the freight goods along the intermodal transport chain. The most commonly used loading unit in European Union is the 40'-container. Other loading units can be swap bodies, semi-trailers or tractor units.

Minimum competitive distance is a metric to compare the profitability of a train with another transport mode, often trucks. The minimum competitive distance captures the distance where rail becomes more attractive to shippers than the other transport mode, typically when the price (or quality-adjusted price) for rail transport is lower than when using the other transport mode.

Single-wagon transport refers to a train type that can deliver goods door-to-door without modal change if both origin and destination are connected to the railway network. Single-wagon transport entails a main leg with a multitude of wagons, and a local feeder and a distribution leg. Local feeder brings the wagon from the origin destination, such as a factory, to the start or intermediary point of the main leg. Distribution leg takes care of the delivery of the wagon to the destination point. Single-wagon transport provides multi-client service since the main leg locomotive transports wagons of different clients.

Railway infrastructure: the ensemble of service facilities, intermodal terminals, private sidings and national railway networks.

Railway undertaking is an undertaking operating and offering rail freight transport. This can include the transport of intermodal units via rail.

Transport volumes in tkm (tonne-kilometre) is the measure commonly used in the report to assess transport volume and represents the total weight of freight in tonnes transported per one kilometre.

Transport volumes in tonnes is the measure we use in the study to compute modal shares at the European and country level. It represents the total weight of freight transported in tonnes, irrespective of the distance.

Annex 3 Study questions

List of study questions provided in the technical specifications of the call for tenders.

	Subsection in the draft final report
Cost and revenue structure of rail freight transport	
Q1: What is the cost-revenue structure of rail freight transport in terms of unit transport costs, (i) overall, (ii) for the main freight categories and main market segments, and (iii) as compared to road-only transport?	Section 5.2, Annex 5.2, Annex 8.2, Annex 20
Q2: To what extent is each of the main markets segments a price taker or a price setter and how does this affect their profitability?	Section 5.7 , Section 6.3
Q3: What is the price-elasticity of the demand in the different main freight categories as well as in the different main market segments? To what extent are lower prices possible and sustainable?	Section 5.7, Annex 26
Q4: How does the cross-border dimension of services affect the cost and revenue structure of rail freight transport?	Section 5.2.6, Section 6.5, Annex 22
Q5: The longer the rail journey and the train, the more competitive freight transport by rail becomes. *a) What is the critical distance for rail freight transport services to be cost-covering in the three main market segments of rail freight transport, i.e. single wagonload, block trains, combined transport trains?* b) *What is the estimated train length, in relation to its composition (number and type of wagons) that ensures the financial break-even?*	Section 5.3, Section 6.4, Annex 21
Short- and long-distance freight operations	
Q6: What is the market structure of (i) short-distance and (ii) long-distance rail freight services?	Section 5.4.3, Annex 8.4, Annex 24
Q7: Are there examples of structurally loss-making (i) short-distance and (ii) long-distance rail freight services? For which market segments and geographical coverage? What type of financial incentives would render those services economically viable?	Section 5.2, Section 6.8
Q8: Some Member States set up incentive schemes in the form of 3-year "start-up" aid to new freight combined transport services. Did the 3-year duration and the structure of those incentives prove appropriate to reach the viability of the subsidized services? If not, what would have been the economically appropriate duration and structure of the incentives in relation to the characteristic of the underlying services?	Section 5.8.4
Intermodal operations	
Q9: *What is the cost-revenue structure including concrete figures of intermodal transport (i) rail/road, (ii) inland waterway/road and (iii) short-sea/road operation? What are the key factors affecting profitability of each category of intermodal transport?*	Section 5.6, Annex 23, Annex 25

Q10: *As regards combined transport road/rail, what is the difference in the cost-revenue structure of accompanied and non-accompanied combined transport?*	Section 5.6.2.2
Q11: *What is the lowest, highest and average value of the minimum length of the rail leg, which makes the total cost of door-to-door intermodal transport operations cost covering or equal to road-only transport on same distances? If the situation is very diverse in Member States, please refer to qualitative homogeneous groups of Member States.*	Section 5.4, Annex 5.4, Annex 8.3
Q12: *According to current rules, the aid amount that can be granted for rail infrastructure use and for reducing external costs without requiring Member States to demonstrate the need and proportionality of the aid is 30% of the total cost of rail transport. Is such a threshold still economically relevant?*	Section 5.8.2.1
Q13: *What is the expected future investment in terminals (i) to increase the demand to a level that makes the operation of the terminal reach the break-even; and (ii) to achieve the goal of doubling rail freight traffic by 2050, as set out in the Sustainable and Smart Mobility Strategy?*	Section 3.4
Q14: Would specific aid to intermodal solutions for freight transport, which combine the use of sustainable modes of transport (e.g. electric vehicles – with smaller than combustion engines range) with rail, lead to the increase of the demand for rail freight services and ultimately make rail freight more convenient as compared to freight transport by road?	Section 4.6.3
Q15: According to current rules, the aid to freight transport services is presumed to be proportionate if it does not exceed 50% of the eligible costs, and the eligible costs are the part of the external costs which rail transport makes it possible to avoid compared with competing transport modes. Based on the cost-revenue structure of the main freight transport services referred in the questions above, are there cases where such aid would differ from the actual cost of the subsidized service?	Section 5.8.2.2
Q16: According to current rules, if the aid is granted to the railway undertaking, it has to be reflected in the price demanded from the passenger or from the shipper, since it is they who make the choice between rail and the more polluting transport modes such as road. The same principle applies also to intermodal transport combining road leg with short-sea leg or with inland waterway leg. Is there economic evidence that the aid to support the demand of rail freight services (aid to clients, shippers, freight logistics service providers …) is more efficient of the aid to support the offer of rail freight services (aid to railway undertakings)?	Section 6.2
Rolling stock	
Q17: What is the incidence in percentage points of the cost of depreciation and of the cost of maintenance of rolling stock (locomotives and wagons) in the cost structure of (i) rail freight transport and (ii) rail passenger transport? What is the observable difference between book value and market value of the freight and passenger rolling stock?	(i) – (ii) Section 4.3; Section 4.4.3
Q18: What is the average age of existing (i) rail freight rolling stock (at least per category of specialized rolling stock referred to in footnote 4 of the TS) and (ii) rail passenger rolling stock (regional, high speed, regular long-distance and night train services)? Is the level of private financing sufficient to ensure a renewal (i) of the freight rolling stock fleet and (ii) of the passenger rolling stock fleet (regional, high speed, regular long-distance and night train services)?	Section 4.4, Annex 10, Annex 12
Q19: What is the cost of the introduction of new technologies in rolling stock, such as Automated Train Operation, the future radio system, or Digital Automated Coupling, Future Railway Mobile Communication System ("FRMCS") or the "Gigabit Train" concept? What is the business case for introducing such new functionalities and technologies, and what are the barriers to implementation?	Section 4.5, Annex 12

Q20: What is the percentage out of the total fleet of the used rolling stock owned by rail incumbents (i) that they lease or sell on the market and (ii) that they scrap? What is the average remaining life cycle and technology of the rolling stock scrapped by rail incumbents? What is the percentage out of the total scrapped rolling stock that could not be reused or retrofitted due to economic, technical and/or environmental reasons?	Section 4.3, Annex 12
Q21: What is the net extra cost of rolling stock using clean technologies as compared to diesel rolling stock? What is the nature and economic value of the investments in retrofitting of passenger and freight rolling stock?	Section 4.5
Q22: Has any Member State put in place any measure for the reduction of track access charges linked to the innovative nature and/or environmentally friendly nature of the rolling stock used?	Section 5.8.3
Rail transport infrastructure and service facilities	
Q23: Is there evidence of a lack in essential service facilities described in point 2 of Annex II to EU Directive 2012/34, including freight terminals, marshalling yards and train formation facilities, including shunting facilities, storage sidings, maintenance facilities, technical facilities such as cleaning and washing facilities, refuelling facilities? The analysis should cover the density, the individual and aggregated capacity, the obsolescence and any other dimension deemed relevant and duly justified by the contractor.	Section 3.3, Annex 3.1, Annex 5.3, Annex 11, Annex 12
Q24: Is there evidence of a lack in intermodal terminals?	Section 3.4, Section 3.6.1
Q25-26: What is the cost and the business case for the construction of private railway sidings? The Contractor should identify the factors that drive the need for public aid.[452]	Section 3.5, Section 3.6.2, Annex 9
State support measures	
Q27: What are the State support measures (provided from national budget) in the EU and Switzerland that are designed to directly support: *-rail freight transports services;* *-passenger and freight rolling stock; and* *-intermodal infrastructure and intermodal services pursuing the modal shirt of freight traffic from road to rail or maritime or inland waterway.* *-investments promoting greater safety, the removal of technical barriers and the reduction of notice and other environmental pollution?*	Section 2.4.1, Section 3.6, Section 4.6, Section 5.8, Annex 6
Q28: What is the evidence (e.g. reports), if any, of the impact of those measures in respect to the objectives pursued, in particular on fostering modal shift to rail?	Section 2.4.3
Q29: What is the evidence that the past financing has been reflected in the price demanded form the passenger or from the shipper?	Section 6.1, Annex 7

Annex 4 Interviews

Table 29: List of interviews conducted during stakeholder consultation

Interviewee	Subjects	Date
Verband Deutscher Verkehrsunternehmen (German industry association)	German market structure; cost structure; border-crossings	09.03.2022

[452] Please note that the Consortium has rephrased questions 25 and 26 with respect to their original drafting in the TS, following discussions with the Commission which provided clarifications as to the objective of these study questions.

Roland Berger (Consultant)	Methodology and limimtations to derive cost structure as in Roland Berger (2021)	15.03.2022
ProRail (Dutch Infrastructure manager)		31.03.2022
ÖBB Infrastruktur (Austrian infrastructure manager)	Clarification data request and data availability	06.04.2022
Bundesnetzagentur (German regulator)	Price elasticities	07.04.2022
Trieste Marine Terminal (Italian terminal operator)	Terminal profitability; intermodal transport chain; subsidy effectiveness	12.04.2022
ÖBB Holding (Austrian incumbent)	Austrian market structure; intermodal transport chain; survey feedback	13.04.2022
Metrans (Czech terminal operator)	Czech market structure; terminal profitability; intermodal transport chain; subsidy effectiveness	14.04.2022
Rotterdam World Gateway (Dutch terminal operator)	Dutch market structure; terminal profitability; intermodal transport chain; subsidy effectiveness	26.04.2022
European Union Agency for Railways (European regulator)	Interoperability of rolling stock and infrastructure; rolling stock characteristics; national vehicle registers	27.04.2022
Verband Deutscher Verkehrsunternehmen (German industry association)	Complementary rail services (marshalling/shunting; regional distribution); rail profitability	02.05.2022
ERFA Gleisanschluss (German consultancy)	Business case for the construction of private sidings;	06.05.2022
DB Netz (German infrastructure manager)	Clarification data request and data availability	18.05.2022
Verband Deutscher Verkehrsunternehmen (German industry association)	Pricing mechanisms by train types; competition between road and rail	18.05.2022
Związek Niezależnych Przewoźników Kolejowych (Polish industry association)	Polish rail freight market, trends, profitability factors and policy options to foster the modal shift to rail.	01.06.2022
Asociación de Empresas Ferroviarias Privadas (Spanish industry association)	Spanish market structure; gauge change; effectiveness of aid	02.06.2022
Autorité de régulation des transports (French regulator)	Profitability rail sector; pricing; operation of short-distance RU	07.06.2022
Opérateurs ferroviaires de proximité (French industry association)	French market structure; short-distance RU; profitability; pricing; inter-mode playing field	10.06.2022
LTG Cargo (Lithuanian incumbent)	Lithuanian market structure; shift to intermodal transport; gauge change; pricing mechanisms	22.06.2022
Europe's Rail Joint Undertaking (Research partnership)	Access to rolling stock; status of rolling stock fleets; innovative technologies	27.06.2022

FerCargo (Italian industry association)	Italian market structure;	28.06.2022
XRail (cross-European association for single-wagon transport)	Copmetitive situation single-wagon; cross-border; infrastructure	29.06.2022
SNCF Fret (French incumbent)	French market structure, break-even in terms of distance and number of wagons	06.07.2022
International Union of Wagon Keepers (cross-European association)	Access to rolling stock; status of rolling stock fleets; introduction of innovative technologies	06.07.2022
European Rail Freight Agency (cross-European association)	Access to rolling stock; status of rolling stock fleets; introduction of innovative technologies	13.07.2022
Alliance of Passenger Rail New Entrants in Europe (cross-European association)	Access to rolling stock; status of rolling stock fleets; introduction of innovative technologies	13.07.2022
Kreisbahn Siegen-Wittgenstein (German short-distance operator)	Business model and profitability of short-distance operators; system and future of single-wagon system; cost of infrastructure; appropriateness of State aid	16.09.2022
RDT 13 (French short-distance operator)	Business model and profitability of French OFP; planned project to boost volumes with State aid; efficient provision of State aid; operators that exert competitive pressure	21.09.2022
Lotos (Polish non-incumbent)	Busines model and profitability of single-wagon and short-distance operations; network density and available infrastructure; combining block train with single-wagon operations	27.09.2022
Community of European Railway and Infrastructure Companies (cross-European association)	Supply structure of basic service facilities and the market participants active in the market	15.09.2022
One of the main association representing vehicle owners (cross-European association)	Value of rolling stock; the second-hand market; new technologies	16.09.2022
BASF	User capacity of intermodal terminals; price of the transshipment	22.09.2022

Source: The Consortium.

Annex 5 Overview of the survey

The following annex provides an overview of all efforts undertaken and results achieved by the study team ("Team") on the survey for the impact assessment support study regarding the review of the Community guidelines on State aid for railway undertakings.

The Consortium undertook best efforts to contact sufficient stakeholders in pursuit of this objective, including manifold additional steps and mitigating measures seeking to acquire a representative sample of responses. In this regard, the Consortium proposed follow-up interviews to the relevant stakeholders contacted previously, either by telephone or online. Numerous stakeholders accepted interviews to be conducted, which led to additional insights into the market. The Consortium also identified alternative targets from the same categories of stakeholders and sent them the questionnaire for written response. Moreover, the Consortium drafted a shortened questionnaire for railway undertakings and national authorities in order to lower the burden for those stakeholders to respond. This measure led to additional replies being handed in by stakeholders.

In total, 79 stakeholders replied to the survey, either by filling out the questionnaires or by accepting to conduct an interview with the Consortium. Through all these tools, the Consortium was able to secure a representative sample of replies, giving a proper overview of the state of play in the rail freight industry and the positions taken by the different categories of stakeholders in this industry.

Stakeholder identification and questionnaires

For the targeted stakeholder consultation, the Consortium identified key stakeholders active in the railway and transport sector. They comprise granting authorities at national and regional level, national regulatory bodies, infrastructure managers, national industry associations (both representing railway undertakings, inland waterway operators, and logistics companies and/or multimodal transport operators), as well as incumbent and commercial railway operators with a focus on freight, inland waterway operators, and logistics and rolling stock leasing companies. Moreover, the key stakeholders also include EU agencies, European umbrella industry associations as well as other associations at the EU level.

As regards the geographic dimension, the key stakeholders are established in the 11 pre-selected countries (i.e. Austria, Czech Republic, France, Germany, Italy, Sweden, the Netherlands, Poland, Romania, Spain, and Switzerland) and in two additional countries, Lithuania and Slovakia. In total the Consortium identified over 700 stakeholders from the respective countries and stakeholder categories outlined above.

The stakeholder consultation, which covered the period from 1 January 2018 to 30 September 2021, was focused on key questions regarding the cost-revenue structure, profitability and future investment in rail freight transport, intermodal transport and in freight services. Moreover, the consultation sought to establish certain data on rolling stock and infrastructure. In addition, the Consortium asked specific questions related to State aid and State support measures to granting authorities as a separate stakeholder group.

Due to the large amount of questions in the TS and in order to carry out a targeted survey, the Consortium identified nine groups of stakeholders and drafted specific questionnaires for each of them: (1.) National and regional granting authorities; (2.) Rail transport regulators; (3.) National rail infrastructure managers; (4) Rolling stock leasing companies (wagon keepers); (5.) European umbrella industry associations; (6.) National industry associations; (7.) Railway undertakings (incumbent and commercial entrants); (8.) Inland waterway operators; and (9.) Logistics companies and/or multimodal transport operators.

Implementation of survey

The different questionnaires were sent, together with the comfort letter provided by the Commission, to all the different stakeholder groups. The Consortium followed-up either with calls to the stakeholders and/or email reminders in order to make sure that the questionnaire reached the competent person within the company/organisation. Certain stakeholders requested the relevant questionnaire to be translated into the language of the Member State in which the stakeholder is located (for instance German and French), which was provided by the Consortium.

The Consortium received a total of 48 filled-out questionnaires from the following stakeholder groups:

- 3 replies from European umbrella associations
- 2 from an infrastructure manager
- 11 from national market regulators
- 3 from inland waterway operators

- 8 from rolling stock leasing companies
- 6 from granting authorities
- 13 from railway undertakings
- 2 from intermodal operators

As regards the separate data request for Registration Entities (REs), the response rate was fairly high (69%). Out of 13 approached REs, 9 provided their data (France, Germany, Italy, Lithuania, the Netherlands, Poland, Romania, Slovakia, and Spain) which often had been clarified with follow-on questions to the REs to which they responded.

In addition to that the Consortium addressed separate data request to the infrastructure managers, 7 of which provided answers (Austria, Germany, Lithuania, Netherlands, Poland, Spain, Sweden). One of them (Poland) provided the Consortium with answers to both the questionnaire and the data request. This will be counted as two separate written replies coming from the same stakeholder.

This brings the overall number of written replies to 63.

In addition, the Consortium conducted 30 interviews, among which 7 with stakeholders who had previously also provided written responses, and 17 with stakeholders who did not respond to the questionnaires but agreed to respond through an interview. Adding these 17 responses to the 63 written replies brings the total number of responses achieved by the Consortium as part of the survey to 86.

The Consortium interviewed the following stakeholder groups of interest:

- 5 European umbrella associations
- 6 national industry associations
- 3 infrastructure managers
- 2 national market regulators
- 3 intermodal operators
- 6 railway undertakings

The Consortium found certain difficulties when attempting to maximize the response rate, mainly due to time constraints of the stakeholders to complete the written questionnaires, insufficient data held by the stakeholders to successfully answer to the questions, the sensitive character of such data and the general complexity of contacting the responsible member with the capacity to complete the questionnaire within the stakeholder structural organisation. In order to tackle these obstacles, the following mitigation measures were applied.

Mitigation measures

The Consortium applied several mitigation strategies in order to increase the response rate: significantly shortened questionnaires were sent to railway undertakings and market regulators. These new questionnaires were sent out from 24th May 2022 onwards. Thanks to this mitigation measure, the Consortium received 4 additional replies, and this proved to be a useful measure specifically in Lithuania. Most of the stakeholders, however, did not react to this shortened questionnaire either.

With support by the European Commission, the Consortium provided lists of contacted stakeholders and the respective email communication to the Swedish, Polish, and Italian authorities, which agreed to reach out to the stakeholders to encourage them to participate in the survey. The success of this mitigation measure is difficult to measure as there is no clear indication whether a reply was sent to the Consortium due to this intervention and pressure of the national authority.

The Consortium pushed for interviews with stakeholders who were hesitating to provide detailed information in writing. This led to interviews with several additional key stakeholders, which provided valuable input and background information to the study.

Overall outcome

Despite all the obstacles mentioned above, the Consortium was able to achieve a rsample of replies representing all selected countries and all stakeholder categories, giving a meaningful overview of the state of play in the rail freight industry and the positions taken by the different stakeholders within this industry. A representative picture in terms of geography was in particular provided by national market regulators.

The Consortium received replies from all approached countries and from each of the approached stakeholder groups (often from different countries). On this basis, it can be concluded that the Consortium managed to achieve a sufficiently meaningful sample which allows the Commission to draw the necessary conclusions as regards any necessary policy amendments in the sector.

Annex 6 [Confidential] Annexes with confidential information

Annex 7 List of relevant State aid decisions

Member State	State Aid (Y/N)	Case Code(s)	Name of Scheme (English)
Austria	Y	SA.33669	ERP Transport Program
Austria	Y	SA.33993, SA.48390, SA.55507, SA.57371, SA.60655, SA.63825	Aid for the provision of certain combined transport services by rail in Austria.
Austria	Y	SA.34985, SA.48485	Intermodal Transfer Guidelines/Guidelines on the construction of private railway connections
Austria	Y	SA.41100, SA.60142	Programme of Aid for Innovative Combined Transport
Austria	N	-	Concessions on Road Tax
Austria	N	-	Mobility of the Future
Belgium	Y	SA.36207, SA.42388, SA.60451	Support scheme for intermodal transport of containers on waterways in the Brussels Region
Belgium	Y	SA.38611, SA.41472, SA.47109, SA.57556	Promotion of combined (intermodal transport units) and distributed freight transport by rail
Belgium	Y	SA.37293, SA.58023	Aid scheme for alternative modes of transport to the road
Belgium	Y	SA.50584	Structural aid measure reducing the cost disadvantage of bundling volumes transported by rail/inland waterways to and from Flemish seaports in order to promote a modal shift
Belgium	Y	SA.60499	Aid scheme for retrofitting wagons to reduce noise pollution from rail freight transport
Belgium	Y	SA.60177	Aid scheme improving the quality of intermodal connections to and from Flemish seaports

Bulgaria	Y	SA.31250	Measure implemented by Bulgaria in favour of BDZ Holding EAD SA, BDZ Passenger EOOD and BDZ Cargo EOOD
Croatia	Y	SA.39877	Aid to HZ Cargo - Debt cancellation
Croatia	Y	SA.47429, SA.52828	Incentives for combined transport in Croatia
Croatia	Y	SA.43109	Aid for the CONSTRUCTION OF a BULK CARGO TERMINAL IN the PORT OF OSIJEK
Czech Republic	Y	SA.35948, SA.38115	Prolongation of the interoperability scheme in railway transport
Czech Republic	Y	SA.38003, SA.43080	State aid scheme for operators for the modernisation of inland waterway freight transport vessels
Czech Republic	Y	SA.62018	Support for rail freight operators using electric traction
Czech Republic	Y	SA.39962	Aid scheme for the modernisation and construction of combined transport terminals. Czech Republic.
Czech Republic	Y	SA.49153	Aid for intermodal transport units
Denmark	Y	SA.36758, SA.48634	Subsidy Scheme Rail Freight
Denmark	Y	SA.39078	Financing of the construction of the Fehmarn Belt fixed link
Denmark	Y	SA.38283, SA.57809	ERTMS funding for Danish rail freight operators
Finland	N	-	Finnish Law on vehicle tax (ajoneuvoverolki 1281/2003) - Tax Support for Combined transport that includes transporting the tractor unit in the train
France	Y	SA.33845, SA.40404, SA.51559	Aid Scheme for the experimental service of the Alpine rail motorway
France	Y	SA.35139, SA.48804, SA.57398	Modernisation and Innovation Aid Plan for the river fleet (PAMI)
France	Y	SA.37881, SA.53158	Combined Freight Transport
France	Y	SA.48483	Aid scheme for connected terminal installations (ITE)
France	Y	SA.35575, SA.48332	Aid plan for modal shift towards inland waterway transport (PARM)

France	Y	SA.41651	Aid for the commissioning and operation of the motorway of the sea between the ports of Algeciras and Vigo in Spain and the ports of Le Havre and Nantes Saint-Nazaire in France
France	Y	SA.38714	Investment aid for the Atlantic rail motorway project
France	Y	SA.35092	Aid for the “Metro of the Future” project
Germany	Y	SA.51956, SA.62763, SA.63635	Aid Scheme for the promotion of Rail Freight Transport
Germany	Y	SA.34156, SA.48972, SA.57271	The Funding Guidelines for noise reduction measures on freight wagons
Germany	Y	SA.50165	Support for the promotion of energy efficiency in rail transport
Germany	Y	SA.54102, SA.56001	Individual aid measures to support rail freight transport infrastructure in Saxony-Anhalt
Germany	Y	SA.63846	COVID-19 – Damage compensation for Deutsche Bahn AG
Germany	Y	SA.46644	Aid for the construction of railway tracks in the port of Lübeck
Germany	Y	SA.46569	Extension of the inland port of Magdeburg
Germany	Y	SA.35363, SA.46720, SA.58570	Guidelines on the construction, extension and reactivation of private railway sidings
Germany	Y	SA.58046	Support for rail freight transport (single-wagon)
Germany	Y	SA.57137	German aid scheme for modernisation of inland waterway fleet
Germany	Y	SA.55353	Programme to support innovation in rail freight transport
Germany	Y	SA.50395	Offshore-surcharge reduction for railway undertakings in Germany
Germany	Y	SA.43008, SA.46341	Guidelines on funding for Transshipment Facilities for Combined Transport - Aid scheme prolongation
Germany	Y	SA.43852	DeltaPort GmbH & Co. KG
Germany	Y	SA.43666	Reduction of the KWKG surcharge for railways
Germany	Y	SA.38728	Special compensation scheme for railways

Germany	Y	SA.58908	Support for ERTMS and automatic train operation (ATO) in the Stuttgart area
Germany	N	-	Digitalisierung intermodaler Lieferketten - KV4 -0
Greece	Y	SA.32543	Measures in favour of OSE group
Greece	Y	SA.32544	Restructuring of the Greek Railway Group - TRAINOSE S.A.
Hungary	Y	SA.33417	Promotion of single-wagon traffic in Hungary
Hungary	Y	SA.59448	Single-wagon Load Scheme
Hungary	Y	SA.37402	The intermodal development of the Freeport of Budapest
Hungary	Y	SA.39177	The Intermodal Development of the Port of Baja
Hungary	Y	SA.41275	Development of Mohacs Port
Hungary	Y	SA.46672	Exemption from the excise duty of the fuel used in rail and inland waterway transport
Hungary	Y	SA.35448	MFB Public Transport Development and Financing Program
Italy	Y	SA.51229	NORMA RETROFIT: Measures to support the rail transport of goods in Italy
Italy	Y	SA.48858, SA.55606	State aid scheme supporting combined transport in the Province of Bolzano
Italy	Y	SA.46806, SA.55912	Aid for combined transport in the Province of Trento
Italy	Y	SA.41033, SA.52499	Integrated transport scheme in the Province of Trento
Italy	Y	SA.45482, SA.48759, SA.55025	Rail freight transport scheme
Italy	Y	SA.58817	State aid to support freight transport by inland waterways in Italy
Italy	Y	SA.44628, SA.59183	Marebonus
Italy	Y	SA.44627, SA.56718	Ferrobonus – incentive for rail transport

Italy	Y	SA.59376, SA.62762, SA.63652	COVID-19 - Reduction of track access charges for rail freight and commercial rail passenger services
Italy	Y	SA.38152, SA.54990	Aid in favour of rail freight transport in Emilia-Romagna region
Italy	Y	SA.53615	Interventions in favour of the city of Genoa
Italy	Y	SA.34146, SA.39606, SA.51714	Aid Scheme for the experimental service of the Alpine rail motorway
Italy	Y	SA.50115	FVG Region- Intermodal rail transport of iron slabs
Italy	Y	SA.47779	Friuli Venezia Giulia - Interventions for the development of combined transport
Italy	Y	SA.35193	Termini Imerese Port
Italy	Y	SA.35124	Regional Interport of Puglia
Italy	Y	SA.28642	Firmin srl
Italy	Y	SA.34238	Regional aid scheme for private transport and logistics infrastructure in Italian convergence regions
Italy	Y	SA.34940	Port of Augusta
Luxembourg	Y	SA.38229, SA.51613	Aid for the promotion of combined transport for the period 2015-2018
Netherlands	Y	SA.34743, SA.37637, SA.38639	start-up aid project to new combined transport services based on Twin hub railway network
Netherlands	Y	SA.42476	Betuweroute - compensation to rail during construction works 2016 - 2020
Netherlands	Y	SA.52898	Financial measure to stimulate rail freight
Netherlands	Y	SA.55451	Support for ERTMS-upgrade
Poland	Y	SA.55443	Aid for the implementation of projects to reduce noise emissions by freight wagons
Romania	Y	SA.49631, SA.39883	State aid scheme for RO-LA Combined Transport
Romania	Y	SA.40926	Galați multimodal platform

Slovakia	Y	SA.34369	Construction and operation of public intermodal transport terminals
Slovakia	Y	SA.46046	Exemption from the excise duty of the fuel used in the inland waterway transport
Slovenia	Y	SA.62208	Grants to promote rail freight transport in Slovenia
Spain	Y	SA.41620	Start-up aid for motorway of the sea between ports of Algeciras y Vigo in Spain and ports of Havre and Nantes-Saint Nazaire in France
Sweden	Y	SA.43724	Investment in infrastructure at Kvarken Ports (Umeå)
Sweden	Y	SA.46749	Aid for investment in logistics centre in the Port of Pitea
Sweden	Y	SA.50217, SA.56402	Swedish Eco-bonus scheme for short sea shipping and inland waterway transport
Sweden	Y	SA.100464	COVID-19: Reduction of infrastructure access charges for transport services by rail
Sweden	Y	SA.49749, SA.57886, SA.60383, SA.62800	Environmental compensation for rail freight transport
Switzerland	N	-	NEAT (New Railway Link through the Alps)
Switzerland	N	-	GVVG (Freight Traffic Relocation Act)
Switzerland	N	-	LSVA (performance-based heavy vehicle fee)
Switzerland	N	-	Investment contributions for interchange systems for combined transport and sidings
Switzerland	N	-	Construction and financing of the 4-meter corridor
United Kingdom	Y	SA.39354, SA.54860	Mode Shift Revenue Support (MSRS) scheme
United Kingdom	Y	SA.39355	Waterborne Freight Grant (WFG). Maritime aid scheme. UK
United Kingdom	Y	SA.34604, SA.49518	Freight Facilities Grant

Annex 8 Theoretical results on pass through

The rate at which subsidies or taxes are passed through to final prices for consumers is known for its lack of simple predictions. Below some of the simpler results are reported. The discussion below considers a fixed per unit subsidy (tax); a percentage (ad valorem) subsidy or a lump-sum subsidy would generate different results.

Among more complex derivations of pass-through rates, Anderson et al. (2001) consider the case of price competition involving differentiated products, while Ashenfelter et al. (1998) derive separate pass-through rates for: (i) firm-specific marginal cost changes and (ii) marginal cost changes common to all firms.

Monopoly: Bulow and Pfleiderer (1983) show that, in general, the pass-through rate in a monopoly equals the slope of the demand curve divided by the slope of the marginal revenue curve. When expressed in terms of the price elasticity of demand, ε_d, and price, p, the pass-through rate is:

$$\text{Pass-through} = \frac{\varepsilon_d}{1+\varepsilon_d+\left(\frac{p}{\varepsilon_d}\right)\frac{\partial \varepsilon_d}{\partial p}}$$

This equation can be simplified for specific types of demand curve. For a constant elasticity demand curve of the form:

$$p = \beta q^{\frac{1}{\varepsilon_d}}$$

where q is quantity and β is a parameter, the pass-through rate is:

$$\text{Pass-through} = \frac{\varepsilon_d}{1+\varepsilon_d}$$

Whenever $\varepsilon_d < -1$, the pass-through rate will exceed 1, i.e. a unit subsidy will reduce the unit price by more than the value of the subsidy. For a demand curve of the form:

$$p = \alpha - \beta q^{\delta}$$

where α, β and δ are parameters and $\delta > 0$, the pass-through rate is:

$$\text{Pass-through} = \frac{1}{1+\delta}$$

implying a pass-through rate less than 1, i.e. only partial pass-through. A linear demand curve is the special case where $\delta = 1$, in this instance, the pass-through rate for a per unit subsidy is 50%.

Last, the pass-through rate is always 1, i.e. the per unit subsidy is passed through exactly to the price, if the demand curve is of the form:

$$p = \alpha - \beta LNq$$

and $\alpha > 0$, $\beta > 0$ and $0 < q < e^{\left(\frac{\alpha}{\beta}\right)}$.

Perfect competition: Weyl and Fabinger (2013) explain that when an individual firm has no ability to change the price it receives for a product the pass-through-rate is:

$$\text{Pass-through} = \frac{1}{1+\left(\frac{\varepsilon_d}{\varepsilon_s}\right)}$$

where ε_s is the elasticity of the supply curve. However, Weyl and Fabinger are careful to note that this is the pass-through rate for an infinitesimally small change in tax (subsidy). For an actual subsidy change, it is necessary to account for the fact that ε_d and ε_s can change as one moves along the demand and supply curves.

The equations for pass-through are noticeably more complex for imperfect competition or oligopoly.

Generalised Cournot (quantity) competition: Delipalla and Keen (1992) consider n identical firms each producing a single homogeneous product and selecting the quantity they will produce. The model incorporates a conjectural variation parameter, λ, which represents how total industry output increases (i.e. the response of other firms) when firm i increases its output by 1 unit. $\lambda = 1$ is the standard Cournot model, $\lambda = 0$ leads to a 'competitive' outcome where price equals marginal cost, and $\lambda = n$ leads to the maximisation of aggregate profits which is akin to tacit collusion.

Assuming a fixed per unit subsidy and simplifying Delipalla and Keen's model by assuming a constant marginal cost, the pass-through rate is:

$$\text{Pass-through} = \frac{1}{1+\left(\frac{\lambda}{n}\right)\left(\frac{\left(\frac{\partial^2 p}{\partial q^2}\right)q}{\left(\frac{\partial p}{\partial p}\right)}\right)}$$

Where q is the output of the industry as a whole.

In a scenario where firms also face a fixed cost and firms freely enter the industry until profits (net of the fixed cost) are driven to zero – the free-entry equilibrium – the pass-through rate is:

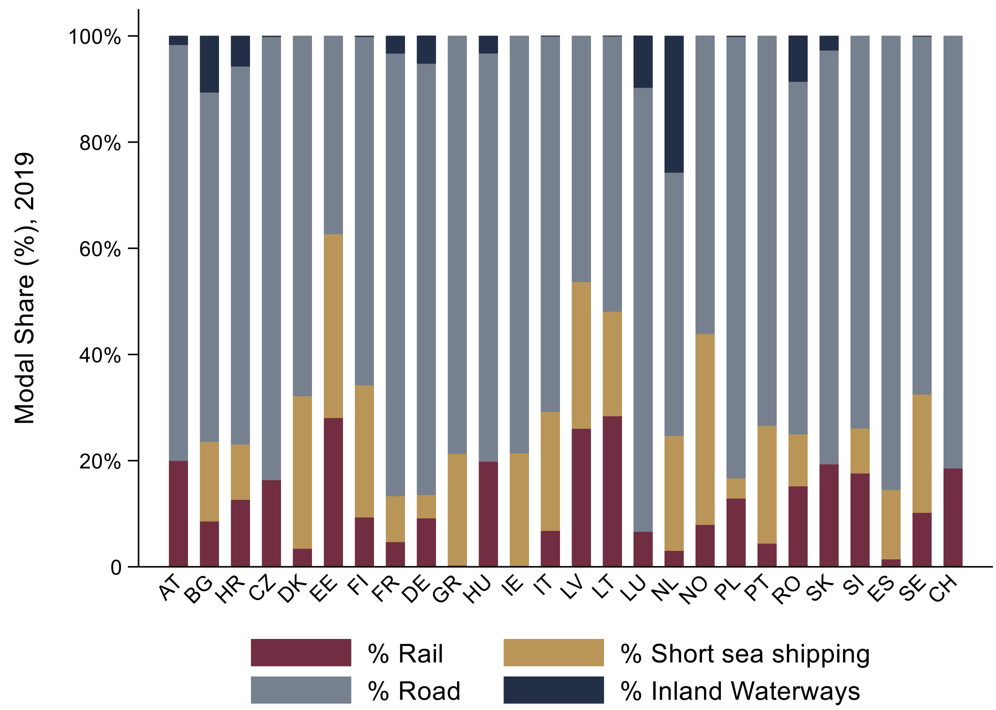
$$\text{Pass-through} = \frac{2}{2+\left(\frac{\lambda}{n}\right)\frac{\left(\frac{\partial^2 p}{\partial q^2}\right)q}{\left(\frac{\partial p}{\partial q}\right)}}$$

In Delipalla and Keen's full model, more complex cost functions and ad valorem taxes (subsidies) are considered, although, the resulting equations for pass-through rates are not reported here due to their complexity.

Annex 9 Rail freight sector overview per Member State

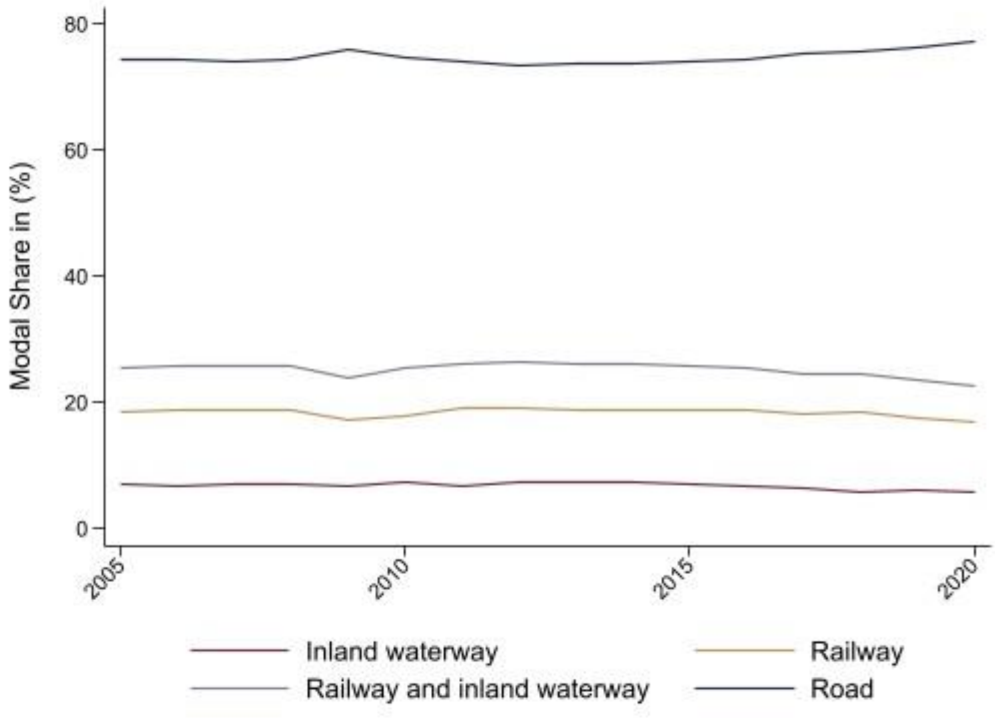
Annex 9.1 Modal shares

Figure 43: Modal share per Member State in 2019 (based on tonnes)



Source: The Consortium based on Eurostat, variables "rail_go_total", "mar_sg_am_cw", "rail_go_ta_tott", and "iww_go_atygo". Note: Values for Belgium could not be considered due to confidentiality while numbers for Greece refer to 2017, the most recent available year.

Figure 44: Inland modal shares (tonnes) in EU27 over time



Source: The Consortium based on Eurostat. Note: shares before 2009 are estimates.

Table 30: Modal share (based on transport volumes in tkm) in 2019

Area	Rail	Short Sea	Road	IWW
Western Europe	15.34	5.87	70.25	8.54
Change (pp*), 2009-2019	0.23	1.08	-0.11	-1.21
Southern Europe	6.62	30.30	62.95	0.14
Change (pp), 2009-2019	1.33	2.84	-4.18	0.02
Eastern Europe	24.82	1.83	68.50	4.85
Change (pp), 2009-2019	-2.34	0.05	3.29	-1.00
Northern Europe	45.23	36.86	0.04	17.86
Change (pp), 2009-2019	-2.73	-1.55	4.26	0.02
EU 24 + CH & NO	14.91	17.0	63.3	4.79
Change (pp), 2009-2019	-1.32	0.57	1.48	-0.73

Source: The Consortium based on Eurostat, variables "rail_go_total", "mar_tp_sss", "road_tert_go", and "iww_go_atygo".

Notes: The Member States included in each group are i) Western Europe: Austria, France, Germany, Luxembourg, Netherlands, and Switzerland ii) Southern Europe: Croatia, Greece, Italy, Portugal, Slovenia, and Spain iii) Eastern Europe: Bulgaria, Czech Republic, Hungary, Poland, Romania, and Slovakia iv) Northern Europe: Denmark, Estonia, Finland, Ireland, Norway, Latvia, Lithuania and Sweden. Values for Belgium could not be considered due to confidentiality. Percentages refer to the average modal share for each mode of transport in 2019, weighted by total freight volumes in tkm for rail, road, and IWW transport.

*For short sea shipping, the national and international intra-EU freight volumes are used instead of total volumes, which would include also extra-EU trade. *pp: Change in percentage points.*

Table 30 reports modal shares based on transport volumes in tkm. For rail, road and inland waterways, the “total transport” measure based on the territoriality principle from Eurostat is considered, which corresponds to the sum of national transport, international transport and transit transport. In the case of short sea shipping, the measure used is instead calculated by summing national transport and intra-EU international transport measures only. For short sea shipping, the extra-EU and transit measures from Eurostat were excluded from the calculation to ensure a higher consistency with the other modes, given that these refer to freight volumes traded between EU MS and non-EU MS (like Russia, Morocco, Libya, Tunisia, Algeria, Egypt, Israel, Occupied Palestinian territory, Lebanon, Syria).

Table 1 in Section 1.3 has the same structure as Table 30 but it reports modal shares based on transport volumes in tonnes instead than in tkm. Table 1 has a higher level of internal consistency than Table 30, since all the indicators taken from Eurostat for the four modes of transport refer to the total transport measure. At the same time, the tkm metric adopted in Table 30 is sometimes preferred to the tonne metric since it allows to account for both the weight of goods transported and the transport distance at the samte time.

Annex 9.2 **Top 5 and 10 rail freight categories per MS, 2019**

Table 31: Abbreviations for freight categories

NST division	Full name	Abbreviation used
1	Products of agriculture, hunting, and forestry; fish and other fishing products	Agriculture products
2	Coal and lignite; crude petroleum and natural gas	Coal and lignite
3	Metal ores and other mining and quarrying products; peat; uranium and thorium ores	Metal ores
4	Food products, beverages and tobacco	Food products
5	Textiles and textile products; leather and leather products	Textiles
6	Wood and products of wood and cork (except furniture); articles of straw and plaiting materials; pulp, paper and paper products; printed matter and recorded media	Wood
7	Coke and refined petroleum products	Coke
8	Chemicals, chemical products, and man-made fibers; rubber and plastic products; nuclear fuel	Chemicals
9	Other non-metallic mineral products	Other non-metallic mineral products
10	Basic metals; fabricated metal products, except machinery and equipment	Basic metals

11	Machinery and equipment n.e.c.; office machinery and computers; electrical machinery and apparatus n.e.c.; radio, television and communication equipment and apparatus; medical, precision and optical instruments; watches and clocks	Machinery and equipment
12	Transport equipment	Transport equipment
13	Furniture; other manufactured goods n.e.c.	Furniture
14	Secondary raw materials; municipal wastes and other wastes	Secondary raw materials
15	Mail, parcels	Mail, parcels
16	Equipment and material utilised in the transport of goods	Equipment
17	Goods moved in the course of household and office removals; baggage and articles accompanying travellers; motor vehicles being moved for repair; other non-market goods n.e.c.	Goods moved in the course of household and office removals
18	Grouped goods: a mixture of types of goods which are transported together	Grouped goods
19	Unidentifiable goods: goods which for any reason cannot be identified and therefore cannot be assigned to groups 01-16.	Unidentifiable goods
20	Other goods n.e.c.	Other goods

Source: The Consortium based on NST 2007 goods classification for transport.

Table 32: Top ten freight categories in Austria in 2019

Rank	Freight Category	% of total transported goods
1	NST 19 - Unidentifiable goods	37.53%
2	NST 3 - Metal ores	9.16%
3	NST 1 - Products of agriculture	7.83%
4	NST 10 - Basic metals	7.41%
5	NST 7 - Coke	6.53%
Top 5 (%)		68.45%
6	NST 6 - Wood	6.12%
7	NST 12 - Transport equipment	6.11%
8	NST 14 - Secondary raw materials	5.86%
9	NST 8 - Chemicals	5.19%
10	NST 2 - Coal and lignite	4.18%
Top 10 (%)		95.9%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 33: Top ten freight categories in Bulgaria in 2019

Rank	Freight Category	% of total transported goods
1	NST 3 - Metal ores	22.23%
2	NST 8 - Chemicals	18.48%
3	NST 7 - Coke	17.59%
4	NST 2 - Coal and lignite	9.45%
5	NST 10 - Basic metals	8.74%
Top 5 (%)		76.48%
6	NST 14 - Secondary raw materials	5.99%
7	NST 9 - Other non-metallic minal products	5.70%
8	NST 20 - Other goods	4.61%
9	NST 4 - Food products	1.89%
10	NST 1 - Products of agriculture	1.55%
Top 10 (%)		96.22%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 34: Top ten freight categories in Croatia in 2019

Rank	Freight Category	% of total transported goods
1	NST 3 - Metal ores	21.75%
2	NST 1 - Products of agriculture	21.13%
3	NST 19 - Unidentifiable goods	15.84%
4	NST 7 - Coke	13.16%
5	NST 8 - Chemicals	7.42%
Top 5 (%)		79.29%
6	NST 10 - Basic metals	5.32%
7	NST 2 - Coal and lignite	5.08%
8	NST 4 - Food products	3.64%
9	NST 9 - Other non-metallic mineral products	2.89%
10	NST 14 - Secondary raw materials	1.68%
Top 10 (%)		97.90%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 35: Top ten freight categories in Czech Republic in 2019

Rank	Freight Category	% of total transported goods

1	NST 18 - Grouped goods	19.04%
2	NST 19 - Unidentifiable goods	17.99%
3	NST 2 - Coal and lignite	14.88%
4	NST 3 - Coke	9.56%
5	NST 1 - Products of agriculture	8.29%
Top 5 (%)		69.75%
6	NST 10 - Basic metals	7.27%
7	NST 8 - Chemicals	5.42%
8	NST 3 - Metal ores	5.06%
9	NST 12 - Transport equipment	4.20%
10	NST 14 - Secondary raw materials	2.68%
Top 10 (%)		94.38%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 36: Top ten freight categories in Denmark in 2019

Rank	Freight Category	% of total transported goods
1	NST 19 - Unidentifiable goods	46.06%
2	NST 6 - Wood	19.25%
3	NST 10 - Basic metals	14.22%
4	NST 14 - Secondary raw materials	3.17%
5	NST 8 - Chemicals	3.09%
Top 5 (%)		85.78%
6	NST 12 - Transport equipment	3.05%
7	NST 18 - Grouped goods	3.01%
8	NST 4 - Food products	2.69%
9	NST 16 - Equipment	1.98%
10	NST 9 - Other non-metallic mineral products	1.86%
Top 10 (%)		98.38%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 37: Top ten freight categories in Estonia in 2019

Rank	Freight Category	% of total transported goods
1	NST 8 - Chemicals	38.98%
2	NST 7 - Coke	35.64%

3	NST 2 - Coal and lignite	13.64%
4	NST 4 - Food products	2.74%
5	NST 17 - Goods moved in the course of household and office removals	2.27%
Top 5 (%)		93.27%
6	NST 3 - Metal ores	1.95%
7	NST 10 - Basic metals	1.72%
8	NST 1 - Products of agriculture	1.07%
9	NST 9 - Other non-metallic mineral products	0.97%
10	NST 11 - Machinery and equipment	0.65%
Top 10 (%)		99.63%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 38: Top ten freight categories in Finlandin 2019

Rank	Freight Category	% of total transported goods
1	NST 1 - Products of agriculture	30.88%
2	NST 3 - Metal ores	19.20%
3	NST 6 - Wood	18.70%
4	NST 8 - Chemicals	14.56%
5	NST 10 - Basic Metals	7.60%
Top 5 (%)		90.94%
6	NST 2 - Coal and lignite	5.45%
7	NST 7 - Coke	2.96%
8	NST 11 - Machinery and equipment	0.18%
9	NST 12 - Transport equipment	0.18%
10	NST 14 - Secondary raw materials	0.15%
Top 10 (%)		99.86%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 39: Top ten freight categories in France in 2019

Rank	Freight Category	% of total transported goods
1	NST 19 - Unidentifiable goods	22.08%
2	NST 18 - Grouped goods	14.20%
3	NST 10 - Basic Metals	13.01%

4	NST 9 - Other non-metallic mineral products	7.30%
5	NST 8 - Chemicals	6.50%
Top 5 (%)		63.08%
6	NST 1 - Products of agriculture	6.19%
7	NST 4 - Food products	6.01%
8	NST 7 - Coke	5.63%
9	NST 20 - Other goods	5.45%
10	NST 3 - Metal ores	4.68%
Top 10 (%)		91.03%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 40: Top ten freight categories in Germany in 2019

Rank	Freight Category	% of total transported goods
1	NST 19 - Unidentifiable goods	38.55%
2	NST 3 - Metal ores	10.24%
3	NST 10 - Basic Metals	9.37%
4	NST 7 - Coke	9.03%
5	NST 8 - Chemicals	6.54%
Top 5 (%)		73.74%
6	NST 12 - Transport equipment	6.54%
7	NST 2 - Coal and lignite	5.77%
8	NST 6 - Wood	5.39%
9	NST 16 - Equipment	3.66%
10	NST 14 - Secondary raw materials	3.06%
Top 10 (%)		98.16%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 41: Top ten freight categories in Greece in 2020

Rank	Freight Category	% of total transported goods
1	NST 16 - Equipment	85.41%
2	NST 10 - Basic metals	7.93%
3	NST 9 - Other non-metallic mineral products	3.24%
4	NST 6 - Wood	1.62%

5	NST 7 - Coke	0.90%
Top 5 (%)		99.10%
6	NST 8 - Chemicals	0.54%
7	NST 1 - Products of agriculture	0.18%
8	NST 2 - Coal and lignite	0.18%
9		
10		
Top 10 (%)		100.00%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood". Values for the year 2019 are confidential.

Table 42: Top ten freight categories in Hungary in 2019

Rank	Freight Category	% of total transported goods
1	NST 3 - Metal ores	15.95%
2	NST 1 - Products of agriculture	13.50%
3	NST 20 - Other goods	11.89%
4	NST 8 - Chemicals	8.03%
5	NST 18 - Grouped goods	6.96%
Top 5 (%)		56.32%
6	NST 7 - Coke	6.86%
7	NST 17 - Goods moved in the course of household and office removals	6.26%
8	NST 19 - Unidentifiable goods	6.22%
9	NST 2 - Coal and lignite	5.65%
10	NST 10 - Basic metals	5.24%
Top 10 (%)		86.55%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 43: Top ten freight categories in Italy in 2019

Rank	Freight Category	% of total transported goods
1	NST 19 - Unidentifiable goods	44.56%
2	NST 10 - Basic metals	14.12%
3	NST 4 - Food products	7.28%
4	NST 1 - Products of agriculture	6.00%
5	NST 8 - Chemicals	5.32%

Top 5 (%)		77.28%
6	NST 18 - Grouped goods	4.72%
7	NST 12 - Transport equipment	4.43%
8	NST 3 - Metal ores	3.00%
9	NST 7 - Coke	2.39%
10	NST 6 - Wood	2.37%
Top 10 (%)		94.18%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 44: Top ten freight categories in Ireland in 2019

Rank	Freight Category	% of total transported goods
1	NST 4 - Food products	61.11%
2	NST 1 - Products of agriculture	22.22%
3	NST 3 - Metal ores	16.67%
4		
5		
Top 5 (%)		100.00%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 45: Top ten freight categories in Latvia in 2019

Rank	Freight Category	% of total transported goods
1	NST 2 - Coal and lignite	42.98%
2	NST 7 - Coke	23.10%
3	NST 8 - Chemicals	10.98%
4	NST 4 - Food products	6.44%
5	NST 1 - Products of agriculture	5.73%
Top 5 (%)		89.23%
6	NST 6 - Wood	4.19%
7	NST 10 - Basic metals	2.80%
8	NST 3 - Metal ores	2.48%
9	NST 19 - Unidentifiable goods	0.45%
10	NST 12 - Transport equipment	0.32%
Top 10 (%)		99.46%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 46: Top ten freight categories in Lithuania in 2019

Rank	Freight Category	% of total transported goods
1	NST 8 - Chemicals	37.70%
2	NST 7 - Coke	19.79%
3	NST 3 - Metal ores	12.18%
4	NST 2 - Coal and lignite	8.07%
5	NST 1 - Products of agriculture	6.36%
Top 5 (%)		84.09%
6	NST 4 - Food products	4.93%
7	NST 10 - Basic metals	4.34%
8	NST 9 - Other non-metallic mineral products	2.83%
9	NST 6 - Wood	1.75%
10	NST 14 - Secondary raw materials	0.82%
Top 10 (%)		98.76%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 47: Top ten freight categories in Luxembourg in 2019

Rank	Freight Category	% of total transported goods
1	NST 10 - Basic Metals	73.30%
2	NST 7 - Coke	18.85%
3	NST 9 - Other non-metallic mineral products	5.76%
4	NST 8 - Chemicals	1.05%
5	NST 20 - Other goods	0.52%
Top 5 (%)		99.48%
6	NST 16 - Equipment	0.52%
7		
8		
9		
10		
Top 10 (%)		100.00%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 48: Top ten freight categories in Netherlands in 2019

Rank	Freight Category	% of total transported goods
1	NST 19 - Unidentifiable goods	40.10%
2	NST 2 - Coal and lignite	19.93%
3	NST 3 - Metal ores	17.37%
4	NST 8 - Chemicals	6.31%
5	NST 10 - Basic metals	6.31%
Top 5 (%)		90.03%
6	NST 12 - Transport equipment	3.43%
7	NST 7 - Coke	1.92%
8	NST 16 - Equipment	1.54%
9	NST 6 - Wood	1.24%
10	NST 9 - Other non-metallic mineral products	1.03%
Top 10 (%)		99.19%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 49: Top ten freight categories in Norway in 2019

Rank	Freight Category	% of total transported goods
1	NST 18 - Grouped goods	55.75%
2	NST 3 - Metal ores	27.36%
3	NST 6 - Wood	10.76%
4	NST 1 - Products of agriculture	3.46%
5	NST 19 - Unidentifiable goods	1.00%
Top 5 (%)		98.33%
6	NST 7 - Coke	0.79%
7	NST 9 - Other non-metallic mineral products	0.33%
8	NST 12 - Transport equipment	0.18%
9	NST 20 - Other goods	0.10%
10	NST 4 - Food products	0.08%
Top 10 (%)		99.82%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 50: Top ten freight categories in Poland in 2019

Rank	Freight Category	% of total transported goods

1	NST 2 - Coal and lignite	27.46%
2	NST 3 - Metal ores	26.52%
3	NST 7 - Coke	17.51%
4	NST 19 - Unidentifiable goods	10.76%
5	NST 8 - Chemicals	5.75%
Top 5 (%)		88.01%
6	NST 10 - Basic metals	3.85%
7	NST 1 - Products of agriculture	1.64%
8	NST 9 - Other non-metallic mineral products	1.40%
9	NST 14 - Secondary raw materials	1.37%
10	NST 12 - Transport equipment	0.91%
Top 10 (%)		97.18%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 51: Top ten freight categories in Portugal in 2019

Rank	Freight Category	% of total transported goods
1	NST 19 - Unidentifiable goods	53.11%
2	NST 1 - Products of agriculture	9.48%
3	NST 7 - Coke	9.24%
4	NST 10 - Basic metals	9.08%
5	NST 3 - Metal ores	7.59%
Top 5 (%)		88.50%
6	NST 9 - Other non-metallic mineral products	3.31%
7	NST 14 - Secondary raw materials	2.74%
8	NST 6 - Wood	2.62%
9	NST 8 - Chemicals	2.46%
10	NST 16 - Equipment	0.32%
Top 10 (%)		99.96%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 52: Top ten freight categories in Romania in 2019

Rank	Freight Category	% of total transported goods
1	NST 7 - Coke	30.21%
2	NST 1 - Products of agriculture	17.47%

3	NST 8 - Chemicals	8.68%
4	NST 2 - Coal and lignite	7.58%
5	NST 19 - Unidentifiable goods	6.41%
Top 5 (%)		70.36%
6	NST 9 - Other non-metallic mineral products	6.04%
7	NST 10 - Basic metals	5.98%
8	NST 6 - Wood	5.84%
9	NST 3 - Metal ores	2.98%
10	NST 14 - Secondary raw materials	2.58%
Top 10 (%)		93.78%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 53: Top ten freight categories in Slovakia in 2019

Rank	Freight Category	% of total transported goods
1	NST 3 - Metal ores	35.44%
2	NST 20 - Other goods	20.49%
3	NST 2 - Coal and lignite	10.41%
4	NST 10 - Basic metals	7.65%
5	NST 1 - Product of agriculture	6.70%
Top 5 (%)		80.70%
6	NST 7 - Coke	6.25%
7	NST 14 - Secondary raw materials	3.87%
8	NST 8 - Chemicals	3.865
9	NST 19 - Unidentifiable goods	2.16%
10	NST 12 - Transport equipment	1.14%
Top 10 (%)		97.98%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 54: Top ten freight categories in Slovenia in 2019

Rank	Freight Category	% of total transported goods
1	NST 19 - Unidentifiable goods	34.37%
2	NST 3 - Metal ores	16.52%
3	NST 2 - Coal and lignite	8.47%

4	NST 10 - Basic metals	7.68%
5	NST 7 - Coke	6.77%
Top 5 (%)		73.81%
6	NST 20 - Other goods	5.89%
7	NST 1 - Products of agriculture	5.66%
8	NST 6 - Wood	3.13%
9	NST 5 - Textiles	3.10%
10	NST 14 - Secondary raw materials	2.83%
Top 10 (%)		94.43%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 55: Top ten freight categories in Spain in 2019

Rank	Freight Category	% of total transported goods
1	NST 19 - Unidentifiable goods	38.05%
2	NST 10 - Basic metals	22.34%
3	NST 18 - Grouped goods	8.11%
4	NST 6 - Wood	5.92%
5	NST 8 - Chemicals	5.73%
Top 5 (%)		80.15%
6	NST 1 - Products of agricuture	5.29%
7	NST 12 - Transport equipment	5.14%
8	NST 5 - Textiles	2.13%
9	NST 2 - Coal and lignite	1.68%
10	NST 7 - Coke	1.64%
Top 10 (%)		96.03%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 56: Top ten freight categories in Sweden in 2019

Rank	Freight Category	% of total transported goods
1	NST 19 - Unidentifiable goods	23.41%
2	NST 3 - Metal ores	21.15%
3	NST 6 - Wood	14.14%
4	NST 10 - Basic metals	12.92%
5	NST 1 - Products of agricuture	12.05%

Top 5 (%)		83.66%
6	NST 8 - Chemicals	3.745
7	NST 14 - Secondary raw materials	2.87%
8	NST 16 - Equipment	2.60%
9	NST 4 - Food products	2.22%
10	NST 12 - Transport equipment	1.90%
Top 10 (%)		96.99%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Table 57: Top ten freight categories in Switzerland in 2019

Rank	Freight Category	% of total transported goods
1	NST 19 - Unidentifiable goods	56.01%
2	NST 10 - Basic metals	7.79%
3	NST 7 - Coke	7.63%
4	NST 4 - Food products	4.18%
5	NST 3 - Metal ores	3.82%
Top 5 (%)		79.43%
6	NST 20 - Other goods	3.04%
7	NST 15 - Mail, parcels	2.98%
8	NST 8 - Chemicals	2.65%
9	NST 18 - Grouped goods	2.10%
10	NST 9 - Other non-metallic mineral products	2.02%
Top 10 (%)		92.22%

Source: The Consortium based on Eurostat, variable "rail_go_grpgood".

Annex 9.3 **Average transport distance on international intermodal routes**

To analyse the length of the rail leg for international intermodal transport operations, the Consortium used data from UIRR (2019, pp.36-37)[453] exhibiting the average distance and the gross weight of freight between any two EU countries. Based on this, Table 58 presents the average distances of rail transport for each origin country in 2018, based on data from the UIRR members.

[453] The *Union Internationale pour le Transport Combiné* (UIRR) is an industry association for the sector of Combined Transport (intermodal transport according to the definitions adopted in this study). It is composed of intermodal transport operators/organisers and intermodal transport terminal owners.

Table 58: Average transport distance of the rail leg for international rail/road intermodal transport

Country of origin	Gross weight (tonnes)	Average distance (km)
Austria	2,977,411	618
Belgium	6,281,032	1,061
Bulgaria*	146	2,510
Switzerland	873,911	701
Czech Republic	608,844	809
Germany	17,377,096	1,149
Denmark	149,586	1,122
Spain	711,049	1,441
France	1,735,635	1,223
Greece	131,945	1,188
Croatia	54,664	542
Hungary	1,115,046	819
Ireland*	7	3,947
Italy	13,116,802	933
Lithuania		-
Luxembourg	653,346	619
Netherlands	2,799,075	828
Norway	13,544	1,388
Poland	147,272	1,216
Portugal*	402	2,732
Romania	290,154	1,571
Serbia	68,771	682
Sweden	742,970	1,120
Slovenia	1,598,286	550
Slovakia	167,838	1,488

*Source: The Consortium based on UIRR (2019). Notes: The average distance was weighted by the gross weight of freight going to each destination country. Figures for Estonia and Latvia are not available. * Those countries provide very few data points. Values may be unreliable.*

Based on Table 58, the country with the lowest travel distance is Slovenia, where the route Slovenia-Hungary has a distance of 75 km. The highest travel distance is found in Norway with 1371 km, this route corresponds to the transport between Norway and Germany. Baring these outliers, the majority of distances hover between 200 and

600km, so they corroborate the conjectures and sources presented in Section 4.3 and Section 4.4.

Annex 9.4 Supplier structure of rail freight transport per Member State

Table 59: Detailed market structure of rail freight transport per MS, 2019

Country	% domestic incumbent	Active freight RU	RU/Billion tkm	HHI ntkm, 2018
Austria	68%	38	1.75	4897
Belgium	70%	12	:	5271
Bulgaria	57%	14	3.59	:
Croatia	61%	10	3.44	4624
Czech Republic	71%	96	5.93	4433
Denmark	0%	5	1.98	:
Estonia	0%	3	1.39	9662
Finland	98%	2	0.19	9744
France	68%	27	0.80	3422
Germany	46%	231	1.93	2409
Greece	98%	2	:	9451
Hungary	49%	28	2.64	2672
Ireland	100%	1	13.89	:
Italy	46%	23	1.08	2554
Latvia	69%	4	0.27	5163
Lithuania	100%	2	0.12	10000
Luxembourg	100%	1	5.24	10000
Netherlands	0%	31	4.38	3752
Norway	44%	6	1.54	3116
Poland	50%	85	1.56	2548
Portugal	0%	2	0.81	7641
Romania	27%	20	1.50	2116
Slovakia	72%	44	5.41	:
Slovenia	83%	7	1.32	7372
Spain	59%	12	1.12	3788

Sweden	49%	11	0.50	3494
Switzerland	69%	25	2.14	3630

Source: The Consortium based on IRG´s 9th and 8th Market Monitoring Report and Eurostat (variable: "rail_go_total"). Note: Values marked as ":" are not available or confidential.

Annex 10 The simple linear regression model

The information provided in this annex is based on Wooldridge (2012) "Introductory Econometrics: a modern approach".

The simple linear regression model aims at explaining how a variable y (the dependent variable) changes in response to variations of a variable x (the explanatory variable). A textbook example of such a relationship is the one existing between education and wages: how much does somebody's wage increase with one extra year of formal education?

The simple linear model can be written down as an equation:

$$y_i = \beta_0 + \beta_1 * x_i + u_i.$$

Where:

- y_i is the observed dependent variable (e.g., the wage) for individual/observation i;
- x_i is the observed explanatory variable (e.g., years of education) for individual i;
- α is the intercept of the equation, and is known as "constant";
- u_i is the error terms, which captures all the factors affecting y_i other than x_i;
- β_1 represents the average effect of a one unit change in x_i on y_i.

This last point can be shown by simply computing the derivative of y_i with respect to x_i:

$$\frac{\partial y_i}{\partial x_i} = \beta_1.$$

The model above is purely hypothetical, and cannot be observed. Indeed, it is not possible to know the exact relationship between x and y. Instead, it can be estimated based on the data available. While a discussion of all the assumptions underlying the estimation of the simple linear regression model is beyond the scope of this annex, the model estimates relationships at the mean value of the variables, and it assumes that the mean value of the error term is equal to 0. This means that the estimated model can be written as:

$$\bar{y} = \widehat{\beta_0} + \widehat{\beta_1} * \bar{x}.$$

In which:

- $\bar{y}$ represents the mean value of the dependent variable;
- $\bar{x}$ represents the mean value of the explanatory variable;
- $\widehat{\beta_0}$ represents the estimated constant; and
- $\widehat{\beta_1}$ represents the estimated parameter of interest.

Given the results of the model, the estimated value of the dependent variable ($\hat{y_i}$) can be written as:

$$\hat{y_i} = \widehat{\beta_0} + \widehat{\beta_1} * x_i.$$

Written in this way, it is also possible to interpret the value of the constant (β_0): it is the average value of the dependent variable (y), when the explanatory variable is equal to 0. Indeed:

$$\hat{y_i} = \widehat{\beta_0} + \widehat{\beta_1} * 0 = \widehat{\beta_0}.$$

The (unobserved) error term can therefore be estimated as the difference between the observed value (y_i) and the estimated value ($\hat{y_i}$) of the dependent variable:

$$\hat{u_i} = y_i - \hat{y_i} = y_i - \widehat{\beta_0} - \widehat{\beta_1} * x_i.$$

The simple linear regression model can be expanded to include multiple explanatory variables. This allows to control for other factors that affect both the outcome variable and the parameter of interest (e.g., β_1). For instance, consider the variable k_i, which is equal to 1 if the individual i studied in an ivy league university in the USA, and to 0 otherwise. It is clear that this influences the quality of her education, and therefore the estimated parameter $\widehat{\beta_1}$. The new model can be written as:

$$y_i = \beta_0 + \beta_1 * x_i + \beta_2 * k_i + u_i.$$

Now the estimated parameter $\widehat{\beta_1}$ can be interpreted as the effect of one extra year of education, keeping constant the type of university the individual attended. This can be easily shown considering the difference between two individuals who attended an ivy league and have, respectively, 16 and 17 years of education:

$$\Delta y = \left(\widehat{\beta_0} + \widehat{\beta_1} * 17 + \widehat{\beta_2} * 1\right) - \left(\widehat{\beta_0} + \widehat{\beta_1} * 16 + \widehat{\beta_2} * 1\right) = \widehat{\beta_1}.$$

Thus, the parameter of interest represents the change in the outcome variable when, *ceteris paribus,* the explanatory variable increases by one unit.

Standard error

It can be shown that estimated parameter $\widehat{\beta_1}$ is itself a variable, meaning that it has its own distribution. This variable is centered around the real β_1 (which is the mean of the distribution) and has variance. In general, the lower the variance, the more precise the estimated $\widehat{\beta_1}$.

It can be shown that the variance of the estimator is equal to:

$$var\left(\widehat{\beta_1}\right) = \frac{\sigma^2}{\sum_{i=1}^{n}(x_i - \bar{x})^2}.$$

Where σ^2 is the variance of the residuals, which can be approximated through its own estimator $\widehat{\sigma^2} = \frac{\sum_{i=1}^{n}\widehat{u_i}^2}{(n-2)}$.

The standard error is given by the square root of the variance of $\widehat{\beta_1}$: $\sqrt{var\left(\widehat{\beta_1}\right)} = \sqrt{\frac{\sigma^2}{\sum_{i=1}^{n}(x_i - \bar{x})^2}}$.

Goodness of fit: the R^2

We now need to define a way to understand how well the model fits the data, i.e. how well the explanatory variable explains changes in the outcome variable.

Let us now define the Total Sum of Squares (SST):

$$SST = \sum_{i=1}^{n}(y_i - \overline{y_i})^2.$$

The SST measure the total sample variation, i.e. the dispersion of the observations around the mean. Equivalently, we can define the Explained Sum of Squares (SSE), which measures the variation of the outcome variable which is captured by the model:

$$SSE = \sum_{i=1}^{n}(\hat{y_i} - \overline{y_i})^2.$$

A simple way to measure how good the model fits the data is given by the R^2, which is simply the ratio between the SSE and the SST:

$$R^2 = \frac{SSE}{SST}.$$

By construction the SST is always equal or greater than the SSE, which means that the R^2 will vary between 0 (the model does not explain any variation in the data) and 1 (the model explains all the variation in the data). A higher R^2 is generally preferred.

Annex 11 Equivalent annual cost of private railway sidings

Annex 11.1 The definition of the equivalent annual cost

This annex explains the concepts and the computations needed to calculate the equivalent annual cost (EAC) of an investment, used in Section 2.5.2 to compare the cost of road transport to that of private sidings.

The EAC is the cost of owning, operating and maintaining an asset over its useful life, and allows to compare the present value of different projects over a period. In order to compute the EAC, the initial investment must be divided by the annuity factor, to obtain the present value of the investment, and cost incurred yearly must be added to this, to take into account the operating costs.

The annuity factor is defined as:

$$Annuity\ factor = \frac{1 - \left(\frac{1}{(1+r)^t}\right)}{r}$$

Where r is the cost of capital and t is the expected useful life of the investment. The EAC is thus given by:

$$EAC = \frac{investment}{annuity\ factor} + yearly\ costs.$$

For a private siding, this would be equal to:

$$EAC_{siding} = \frac{Construction\ costs}{Annuity\ factor} + Maintenance\ costs + rail\ transport\ costs * tonnes * siding\ length.$$

This has to be compared to the EAC of moving freight via road, which is given by:

$$Tonne * km_{Road} + C_{road} + \left(\frac{Tonne}{Capacity\ of\ loading\ units}\right) * transshipment.$$

Annex 11.2 Sensitivity analysis

Section 2.5.2 provides an analysis of the EAC of a private railway siding and compares it to the EAC of road haulage to identify the intensity of aid needed for a firm to be indifferent between the two freight transport solutions in a baseline scenario.

To assess the extent to which some of the hypotheses have influenced the results of the analysis, the Consortium has conducted four sensitivity analysis, varying the value of specific variables, one at a time, to see how it affects the aid intensity, keeping every other variable constant. The four variables that have been analysed are:

- the unit construction costs;
- volumes of freight moved per year;
- the economic useful life of the siding; and
- the length of the siding.

Table 10 in section 2.5.2 and Table 60 below presents the results of the analysis.

To choose how to vary the different variables, the Consortium has collected qualitative information from multiple sources, described below:

- unit construction costs: the website of the Aberdeen Carolina and Western Railway reports a unit construction cost between $1-2M/ km. [454] The Response to the stakeholder survey indicated €1.3M/km for a siding built in a specific scenario,

[454] See ACW Railway's website.

with favourable topographic conditions. To reconcile the two figures, the unit construction cost has been chosen to vary between €750,000/KM to €2M/km, in steps of €250,000. This would account for different topographic characteristics;

- volumes of freight moved per year: the website of ERFA Gleisanschluss reports that private sidings make sense when a minimum volume if moved per week, and indicate this volume to be 1000t/week.[455] Starting from this volume, the annual volume has been computed; the annual volume has then been doubled multiple times to see how the dimension of different firms (or the presence of an industrial centre) can affect the business case of building a siding;
- the economic useful life of the siding: being part of the railway network, sidings have a long technical life, up to 40-50 years according to the result of the stakeholder survey. ERFA Gleisanschluss has reported that private firms and National Authorities consider much shorter economics life, as short as 3 years and 10 years respectively. This is due to the reasons discussed in Section 2.5.2. For this reason, the economic life has been varied between 3 years and 25 years in the sensitivity analysis, to account for the effect of expected short or long economic life;
- the length of the siding: sidings can be of variable length. Indeed, the German Railway Market Analysis (2018) reports an average length of 3.3km. Nonetheless, the Consortium has found evidence of sidings long as little as 300m,[456] whereas the economic literature has identified 4km as a maximum for the length of a siding.[457] Thus, the siding length has been varied between 300m and 4km in the sensitivity analysis;
- the cost of rail transport has been computed by increasing the baseline cost by 50%, and increasing each subsequent rail transport cost by the same percentage;
- the cost of road transport has been computed using the cost of dry bulk transport using trucks provided by Panteia (2020) as a reference for the maximum cost. The gap between the cost in the baseline scenario and the cost figure provided by Panteia (2020) has been divided in bins of equal size;
- the cost of capital has been set at a base level of 1%, and doubled for each computation; and
- the annual maintenance costs have started as very low (0.25% and 0.5% of the total cost of construction), and then increased by 0.5% each time.

The results of the sensitivity analysis for the variables not presented in section 2.5.2 are reported in Table 60 below.

Table 60: Sensitivity analysis - ulterior results

Rail transport costs (€/ tkm)	Aid intensity	Road transport costs (€/ tkm)	Aid intensity	Cost of capital	Aid intensity	Annual maintenace costs as % of construction costs	Aid intensity	Length of siding	Aid intensity (based on depreciation value)
0.015	82.4%	0.111	82.4%	1%	79.1%	0.25%	66.2%	0.3	No aid needed
0.023	83.1%	0.162	77.1%	2%	81.9%	0.50%	71.6%	0.5	No aid needed
0.034	84.1%	0.213	71.8%	3%	84.1%	1.00%	82.4%	1	No aid needed

[455] See Was ist ein Gleisanschluss? - ERFA Gleisanschluss (erfa-gleisanschluss.de).
[456] See Disused sidings? DB Cargo sees them as an opportunity for modal shift | RailFreight.com
[457] See Záhumenská, Z., & Gašparík, J. (2017). Supporting the Connection the Logistics Centers to Rail Network. Procedia Engineering, 192, 976–981. https://doi.org/10.1016/j.proeng.2017.06.168.

0.052	85.6%	0.264	66.5%	4%	86.0%	1.50%	93.3%	2	45.6%
0.077	87.8%	0.315	61.2%	5%	87.5%	2.00%	104.1 %	3	69.0%
0.116	91.2%	0.366	55.9%	6%	88.8%	2.50%	114.9 %	4	80.7%

Source: the Consortium.

Annex 12 The National Vehicle Registers

Commission Decision 2007/756/EC has established a common format for the National Vehicle Registers (NVRs). The format has recently been modified by Commission Implementing Decision (EU) 2018/1614, which has set up the European Vehicle Register (EVR) that would replace the NVRs; nonetheless, most MS have not yet finished the migration toward the EVR, therefore a data request has been sent to the national Registration Entities of the countries that are part of the survey sample. Only Germany, Italy, Lithuania, Netherlands, Poland, Slovakia, and Spain have provided data, although the data provided by Netherlands does not cover a period of time long enough to be analysed, and the data provided by Lithuania was only partial and therefore could not be used. Thus, the analyses presented in Section 3 are based on data from the NVRs provided by the other MS.

Annex 12.1 Structure of the NVR

MS are responsible for keeping and updating the NVR, where all vehicles that are allowed to operate in the country should be registered. Vehicles that can operate in multiple MS shall be registered only in the MS where they are first placed into market. The registers have the following format:

- European Vehicle Number (EVN)
- Member State and National Safety Authority
- Manufacturing year
- EC reference
- Reference to the Register of the Rolling Stock
- Restrictions
- Owner
- Keeper
- Entity in charge of maintenance
- Withdrawal
- MS where the vehicle is authorised
- Authorisation number
- Authorisation of placing into service.

The analyses presented in the report are based on data retrieved from Sections 1, 2, 3, 7, 8, 10 and 13 of the NVRs.

Annex 12.2 European Vehicle Number

The EVN is a 12-digits number that uniquely identifies the rolling stock. The structure of the EVN is provided in Appendix 6 of Commission Implementing Decision (EU) 2018/1614 and reported in Table 61. The remainder of the text below explains how to interpret the relevant digits of the EVN.

Table 61: Structure of the EVN

Rolling stock group	Interoperability capability and vehicle type [2 digits]	Country in which the vehicle is registered [2 digits]	Technical characteristics [4 digits]	Serial number [3 digits]	Check digit [1 digit]
Wagons	00 to 09 10 to 19 20 to 29 30 to 39 40 to 49 80 to 89	01 to 99	0000 to 9999	000 to 999	0 to 9
Hauled passenger vehicles	50 to 59 60 to 69 70 to 79		0000 to 9999	000 to 999	
Tractive rolling stock and units in a trainset in fixed or pre-defined formation	90 to 99		0000000 to 8999999 The meaning of these figures is defined by the Member States, eventually by bilateral or multilateral agreement.		
Special vehicles			9000 to 9999	000 to 999	

Source: Commission Implementing Decision (EU) 2018/1614, Appendix 6.

The first two digits of the number identify the type of rolling stock, i.e. freight wagons (00 to 49 and 80 to 89), passenger vehicles (50 to 79), tractive rolling stock (90 to 98) and special vehicles (99).

Part 6 of Appendix 6 provides information on the interpretation of the first two digits of the EVN for freight wagons, part 7 for passenger vehicles, and part 8 for tractive rolling stock and special vehicles. For freight wagons, the two digits relate to whether the track gauge is with axles or bogies (digit 1) or is fixed or variable (digit 2). Wagons identified with numbers 40 and 80 are maintenance related wagons. For passenger vehicles, the first digit identifies whether the vehicle is for domestic traffic (5), a service vehicle (6) or air-conditioned and pressure-tight vehicles (7), whereas the second digit related to the track gauge and other technical specifications. For tractive rolling stock, the second digit identifies the type of traction according to 10 values:

0. Miscellaneous
1. Electric locomotive
2. Diesel locomotive
3. Electric multiple-unit set (high speed)
4. Electric multiple-unit set (except for high speed)
5. Diesel multiple-unit set
6. Specialised trailer
7. Electric shunting engine
8. Diesel shunting engine
9. Special vehicle.

Technical characteristics of freight wagons are provided in part 9 of Appendix 6. The fifth digit is the most relevant one, as it provides information on the type of freight wagon according to the following values:

0. Wagons with opening roof
1. Ordinary covered wagons
2. Special covered wagons
3. Ordinary flat wagons and open high-sided flat wagons
4. Special flat wagons
5. Ordinary open high-sided wagons
6. Special open high-sided wagons
7. Tank wagons
8. Controlled temperature wagons
9. Other special wagons, tank wagons for traffic in powder form and service vans and wagons.

The other digits identify specific characteristics of the wagons, such as the type of gravity unloading[458] or the types of freight the wagon can transport.[459]

Technical characteristics of passenger vehicles are provided in part 10 of Appendix 6. Digits 5 and 6 identify the type of passenger vehicle (5th digit, 1st class and 2nd class seats, couchette cars, sleeping cars) and the number of compartments (6th digit); couchette and sleeping vehicles are identified by the numbers 4, 5 and 7 in the 5th digit. Digits 7 and 8 report the maximum speed of the vehicles (7th digit) and the energy supply (8th digit); for the 7th digit, numbers 0-2 identify vehicles with a maximum speed of 120km/h, 3-6 identify vehicles with a maximum speed of 121-140km/h, 7-8 identify vehicles with a maximum speed of 141-160km/h, and 9 identifies vehicles with a maximum speed above 160km/h.

Annex 12.3 **Withdrawal**

Item 10 of the NVR (Withdrawal) comprises two sub-items:

- 10.1: mode of disposal; and
- 10.2: withdrawal date.

The “mode of disposal” item is numerical code that explains whether the vehicle has a valid active registration, or if the vehicle’s registration has been withdrawn from the NVRs. Table 62 reports the different numerical values and their interpretation, according to Appendix 3 of Commission Decision 2007/756/EC.

Table 62: NVRs withdrawal coding

Code	Withdrawal mode	Description
00	None	The vehicle has a valid registration.
10	Registration suspended No reason specified[460]	The vehicle’s registration is suspended at the request of the owner or keeper or by a decision of the NSA or RE.

[458] Bulk gravity unloading is used to convey large quantities of bulk materials that are not moisture sensitive. They are typically used in freight block trains for conveying bulk ore, coal, coke and stone. (Freight Wagons - Marub SA).
[459] Note that the same wagon can be authorised to transport, for instance, timber, steel, cars, and containers, or cars, grain, cement, fruits and vegetables, and fertilizers.
[460] According to ERA’s ECVVR application guide: “Withdrawal mode “10” […] should be used in situations when because of a certain reason the vehicle “may not operate on the European railway network under the recorded registration”, but this situation may be corrected in the future. For example, this mode may be used “if on the date of deregistration of the currently registered keeper no new keeper has accepted the keeper status” (Section 3.2.3 of the Annex of the NVR Decision) or “if on the date of de-registration of the

11	Registration suspended	The vehicle is destined for storage in working order as an inactive or strategic reserve.
20	Registration transferred	The vehicle is known to be re-registered under a different number or by a different NVR, for continued use on (a whole or part of the) European railway network.
30	De-registered No reason specified	The vehicle's registration for operating on the European railway network has ended without known re-registration.
31	De-registered	The vehicle is destined for continued use as a rail vehicle, outside the European railway network.
32	De-registered	The vehicle is destined for the recovery of major interoperable constituents/modules/spares or major rebuilding.
33	De-registered	The vehicle is destined for scrapping and disposal of materials (including major spares) for recycling.
34	De-registered	The vehicle is destined as 'historic preserved rolling stock' for operation on a segregated network, or for static display, outside the European railway network.

Source: Commission Decision 2007/756/EC, Appendix 3.

The mode of withdrawal allows to identify whether the rolling stock has been scrapped (modes 32 and 33), or has changed owner, keeper or MS (mode 20). The withdrawal date provides the date in which the rolling stock has been de-registered for any of the reasons specified in Table 62.[461]

Annex 12.4 **The analyses in the report**

Based on the different types of rolling stock and interoperability and technical characteristics presented in Annex 12.2, the Consortium has identified 35 different categories of rolling stock.

The classification has been based on information collected through interviews with ERA and with the input of Leeds' ITS experts on the impact of technical and interoperability characteristics on the useful life of rolling stock. Second, certain types of rolling stock have been grouped together (for instance, ordinary and special freight wagons) to ensure an adequate sample size, in order to avoid unreliable estimates.

Freight wagons are classified according to the 1st and 5th digits of the NVR, which identify whether the wagon has rigid axles or bogies, and the type of wagon (e.g., open roof wagons). The total number of classes for freight wagons categories identified is 14. A subtler classification which took into account also the track gauge (i.e., flexible or fixed) was not possible due to issues related to the sample size.

Passenger vehicles are classified not only according to the 1st and 5th digit, but also the 7th, which is related to the maximum speed of the vehicle. The 1st digit distinguishes among vehicles for domestic traffic (if equal to 5), service vehicles (if equal to 6) and air-conditioned vehicles (if equal to 7). Each of these three classes can either be a standard vehicle, or a night transport vehicle (with couchettes or sleeping cars). The last step of classification pertains the maximum speed of the vehicles, which can be greater than 160km/h, or lower. Although 160km/h is not "high-speed", the data collected in the NVR does not account for higher speeds.

former entity in charge of maintenance any new entity has not acknowledged its acceptance of entity in charge of maintenance status".

[461] It should be noted that in some cases the date is missing, and the REs have advised to use the date in which the authorisation of placing in service (item 13 of the NVRs) has been suspended instead.

Locomotives are categorised according to the 2nd digit: miscellaneous locomotives (e.g., steam locomotives) (0), electric locomotives (1), diesel locomotives (2), electric multiple-units locomotives (3 or 4), diesel multiple-units locomotives (5), locomotives with specialised trailer (6), locomotives with electric shunting engine (7), locomotives with diesel shunting engine (8) and special locomotives (9).

The 35 categories identified are:

1. Wagons with opening roof and axles
2. Covered wagons with axles
3. Flat wagons with axles
4. Open high-sided wagons with axles
5. Tank wagons with axles
6. Wagons with controlled temperature and axles
7. Special wagons with axles
8. Wagons with opening roof and bogies
9. Covered wagons with bogies
10. Flat wagons with bogies
11. Open high-sided wagons with bogies
12. Tank wagons with bogies
13. Special wagons with bogies
14. Passenger vehicles for domestic traffic, <160 km/h
15. Passenger vehicles for domestic traffic, >160 km/h
16. Night transport passenger vehicles, <160 km/h
17. Night transport passenger vehicles, >160 km/h
18. Service passenger vehicles, <160 km/h
19. Service passenger vehicles, >160 km/h
20. Service night transport passenger vehicles, <160 km/h
21. Service night transport passenger vehicles, >160 km/h
22. Air-conditioned passenger vehicles, >160 km/h
23. Air-conditioned night transport passenger vehicles, <160 km/h
24. Air-conditioned night transport passenger vehicles, >160 km/h
25. Miscellaneous locomotives
26. Electric locomotives
27. Diesel locomotives
28. Electric multiple-units
29. Diesel multiple-units
30. Locomotives with specialised trailer
31. Electric shunting locomotives
32. Diesel shunting locomotives
33. Special locomotives

Based on this classification, using the data provided by the Registration Entities for Germany, Italy, Poland, Slovakia and Spain, the Consortium has computed the:

- average age per type of rolling stock: computed as the difference between the current year and the manufacturing year for rolling stock with a valid and active registration status;
- useful life per type of rolling stock: first, the difference between the date of withdrawal and the manufacturing year for vehicles with registered withdrawal modes of 33 or 34 (and no re-registration) is computed per type of rolling stock, and a distribution is obtained. Then, the useful life is computed as the mean of the distribution per type of rolling stock;
- percentage of rolling stock scrapped by the incumbent: as the number of vehicles that were owned and kept by the incumbent and have been scrapped (withdrawal modes 33 and 34 and no re-registration), divided by the number of vehicles that were owned and kept by the incumbent (having both a valid registration status and withdrawal mode 11, 31, 32, 33, and 34);

- average remaining life-cycle of rolling stock scrapped by the incumbent: computed as the average of the difference between the age at scrapping (withdrawal modes 33 and 34 and no re-registration) and the useful life defined above, for rolling stock that has been scrapped before it reached the end of its useful life.

Annex 12.5 Result of the quantitative analysis

While the simple linear regression model discussed in Annex 10 is suitable for a continuous outcome variable, it is not for a binary response variable (i.e., a variable which can take the value of 0 or 1; for instance, you can think of this variable as representing whether or not a specific choice, such as buying a house, has been made).

In this case, the aim of the model is to estimate the probability of the event happening, based on the set of explanatory variables available. Mathematically, this can be written as:

$$P(y = 1|x_1, x_2, x_3 \dots) = G(\beta_0 + \beta_1 * x_i + \beta_2 * x_2 + \beta_3 * x_3).$$

Where $G()$ is a function taking values between 0 and 1. For the sake of simplicity, in the following we will write $G(\beta_0 + \beta_1 * x_i + \beta_2 * x_2 + \beta_3 * x_3)$ as $G(z)$. In the Probit model, $G(z)$ is standard normal distribution cumulative function, expressed as an integral of the density function:

$$G(z) = \Phi(z) = \int_{-\infty}^{z} \phi(v)dv$$

And the normal density function is given by:

$$\phi(z) = (2 * \pi)^{\frac{1}{2}} * e^{-\frac{z^2}{2}}.$$

In order to confirm the qualitative results of section 3.4.3, the Consortium has estimated three probit models, which allow to understand how, after controlling for the age of rolling stock (in years) and the size of the fleet (in number of pieces of rolling stock) of different operators, the probability of scrapping rolling stock changes for an incumbent. The results of the models are reported in Table 63.

As for the linear regression model, the constant that is estimated through a probit model represents the mean value when all other variables are zero. In this case, it is the coefficient associated with being an entrant (incumbent=0), with rolling stock with age 0 and no fleet, which means that the constant by itself does not provide any meaningful information as such an occurrence would not be part of the data.

Table 63: Probability of scrapping rolling stock - probit models

VARIABLES	Freight wagons	Passenger rolling stock	Tractive rolling stock
	Coefficient (Standard error) [marginal effect]		
Incumbent	-0.270*** [-8%]	0.945*** [+21%]	0.808*** [+11%]
	(0.00430)	(0.0348)	(0.0150)
Rolling stock age	0.00858***	-0.00341***	0.0126***
	(0.000133)	(0.000583)	(0.000338)
Size of fleet	-0.0000112***	-0.0000477***	-0.000179***

	(0.00000019)	(0.00000425)	(0.00000435)
Constant	-0.813***	-1.301***	-1.928***
	(0.00575)	(0.0446)	(0.0192)
Observations	483,993	32,023	76,821
R^2	0.03	0.03	0.12

*Source: The Consortium based on NVR data. Note: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1 The coefficients reported are not the marginal effects. ; marginal effects reported in squared brackets.*

As can be seen, *ceteris paribus*, the incumbent has a higher probability of scrapping passenger rolling stock and tractive rolling stock, whereas it has a lower probability of scrapping freight wagons.

As can be seen from the equation explaining the probit model, the estimates parameters (i.e., the β) do not represent the effect of a marginal increase of the explanatory variable on the outcome variable (i.e., $\frac{\partial y}{\partial x_1} \neq \beta_1$). Computing the marginal effects at the mean levels of the control variable shows that incumbents have an 8 percentage points lower probability of scrapping freight wagon, and a 21 percentage points and 11 percentage points higher probability of scrapping respectively passenger and tractive rolling stock.

Annex 13 Rail service facilities data

Annex II of Directive 2012/34/EU lists the essential service facilities that provide complementary services to the rail sector, i.e. those facilities to which access shall be granted to RU "under equitable, non-discriminatory and transparent conditions" (Art. 10, Directive 2012/34). Such facilities are:

- passenger stations, their buildings and other facilities;[462]
- rail freight terminals;[463]
- marshalling yards and train formation facilities, including shunting facilities;[464]
- storage sidings;[465]
- maintenance facilities;[466]
- other technical facilities, including cleaning and washing facilities;[467]
- maritime and inland port facilities linked to rail activities;[468]
- relief facilities;[469] and

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[462] Stations for passenger traffic equipped with specific facilities for the access of the passengers and providing related services such as travel information display and suitable location for ticketing services (Directive 2012/34/EU, Annex II).
[463] Freight terminals are installations where services of loading, unloading and transshipment of goods from and to freight trains or wagons are supplied (Article 2 (e) of regulation (EU) 2015/1100).
[464] Railway facility with special layout and technical facilities, where sorting, formation and splitting-up of trains takes place; wagons are sorted for a variety of destinations, using a number of rail tracks (User Manual of Common Portal for Rail Service Facilities, available here).
[465] Storage siding means sidings specifically dedicated to temporary parking of railway vehicles between two assignments (Directive 2012/34/EU, Article 3 (29)).
[466] Area for the provision of rolling stock-related maintenance services. This type includes light and heavy maintenance facilities (User Manual of Common Portal for Rail Service Facilities, available here).
[467] All technical installations and services that are not included in other facility types. Services or equipment provided in such facilities include, e.g., pre-heating, de-icing, air conditioning, washing/cleaning of rolling stock, disinfection of rolling stock, sewage removal and stationary brake test facilities (ibid.).
[468] Service facility with a rail connection, where handling of goods between water and rail is possible. It is considered as a sub-type to other facility types determined by its location in a seaport or inland port area (ibid.).
[469] Facilities providing equipment and infrastructure used to overcome a disruption (derailment, collision or other accidents), such as: a railway crane to remove a fallen tree or large branch from the track, a tow locomotive to pull a defective train, a specially equipped wagon or a specially equipped relief team (ibid.).

- refuelling facilities.[470]

The directive does not provide a technical definition of the services facilities listed in Annex II, as reported in Section 2.2.

Consequently, the role of each facility and the type of services it entails were left open for the interpretation of national authorities, leading to a significant discrepancy in the data reported by each MS to different sources.

Further, the Consortium has noted that the service facilities reported on the online database railfacilitiesportal.eu (RFP) do not cover all MS. For example, data on marshalling yards and maintenance facilities were missing for most of the MS. DG Move (2022),) also noted that RFP's data on intermodal terminals was unreliable, as there are repeated instances in which terminals are either missing, reported as active but closed in reality, or reported multiple times.

As a primary data source for the analyses of section 2.3, the Consortium has relied on the 8th RMMS.[471] As this data is still preliminary, and some countries have not yet provided all the information on the number of service facilities, the Consortium has carried out a cross-validation analysis of the data available therein. As a first step, this data has been checked for consistency over time by looking at previous issues of the RMMS (6th, and 7th). When the Consortium identified either strong inconsistencies over time (such as for marshalling yards in France) or numbers that seemed to contrast with other evidence collected, the data has been checked against information provided in IRG-Rail's reports, national Network Statements, reports issued by MR (for Germany, Poland, and Spain), and other sources. In particular, the national Network Statements of the following countries have been analysed by the Consortium: Austria, Czech Republic, Denmark, Finland, France, Germany, Italy, Luxembourg, Netherlands, Poland, Portugal, Romania, Spain, Slovakia and Sweden.

Gathering data from the Network Statements proved to be a challenge, because often the relevant documents (i.e., the annexes of the Network Statements) were provided only in the original language of the MS; in addition, the data about the service facilities was sometimes accessible only through online portals wherein the facilities were described in a disaggregate manner and not following the nomenclatures set in Annex II of Directive 2012/34/EU (which means that the Consortium had to undertake efforts to reconcile the definitions provided in these online portals with other data sources), or sometimes the portal was only accessible to sector operators (e.g. in Austria and in Denmark).

As a main rule, in case of strong discrepancies between different sources, the Network Statement or the National Regulatory Report (when available), has been preferred to the 8th RMMS. The Consortium has made efforts to ensure that the data presented is as complete, accurate and consistent as possible. Despite these efforts, not all the data entry met the previous criteria. Indeed, for certain facilities or countries only one source was available.

Finally, as data for intermodal terminals is not provided in the RMMS, for this type of facility the main source is the IRG (2020) report.

Table 64 below outlines the list of data sources chosen per facility per country as well the criteria inside the brackets pointing out why the primary source has been discarded and another source was preferred.

[470] Areas which provide fuel for locomotives and other rail vehicles (ibid.).
[471] Data from the yet unpublished 8th RMMS has been provided by DG Move for the purpose of this study.

Table 64: List of data sources used per facility, per country

Country	Passenger stations	Freight terminals	Intermodal terminals	Marshalling yards	Maintenance facilities	Maritime and inland ports	Refuelling facilities
Austria	8th RMMS	8th RMMS	IRG (2020)	NS [Inconistant definitions and values]	8th RMMS	8th RMMS	8th RMMS
Belgium	8th RMMS	8th RMMS	IRG (2020)	8th RMMS	8th RMMS	8th RMMS	8th RMMS
Bulgaria	8th RMMS	8th RMMS	IRG (2020)	8th RMMS	8th RMMS	8th RMMS	8th RMMS
Croatia	8th RMMS	8th RMMS	UIC (2020) [only source]	8th RMMS	8th RMMS	8th RMMS	8th RMMS
Czech Republic	8th RMMS	8th RMMS	IRG (2020)	8th RMMS	8th RMMS	7th RMMS [Only source]	8th RMMS
Denmark	8th RMMS	8th RMMS	UIC (2020) [only source]	NS [Inconistant values]	8th RMMS	8th RMMS	8th RMMS
Estonia	8th RMMS	8th RMMS	UIC (2020) [only source]	No public information available	No public information available	No public information available	No public information available
Finland	NS [Inconsistent values]	8th RMMS	UIC (2020) [only source]	8th RMMS	8th RMMS	8th RMMS	8th RMMS
France	8th RMMS	NS [Inconistant values]	IRG (2020)	8th RMMS	6th RMMS [Only source]	NS [up to date]	NS [Inconistant values]
Germany	8th RMMS	RMAG (2019) [Inconistant values]	IRG (2020)	8th RMMS	8th RMMS	8th RMMS	8th RMMS [Inconistant values]
Greece	8th RMMS	8th RMMS	IRG (2020)	8th RMMS	7th RMMS [Only source]	8th RMMS	8th RMMS
Hungary	8th RMMS	8th RMMS	UIC (2020) [only source]	8th RMMS	8th RMMS	8th RMMS	8th RMMS
Ireland	8th RMMS	RFP [Inconistant values]	UIC (2020) [only source]	8th RMMS	8th RMMS	8th RMMS	8th RMMS
Italy	8th RMMS	8th RMMS	IRG (2020)	8th RMMS	8th RMMS	8th RMMS	8th RMMS
Latvia	8th RMMS	NS [Definition]	IRG (2020)	8th RMMS	8th RMMS	6th RMMS [Only source]	8th RMMS

Lithuania	8th RMMS	8th RMMS	IRG (2020)	8th RMMS	8th RMMS	No public information available	8th RMMS
Luxembourg	8th RMMS	8th RMMS	IRG (2020)	8th RMMS	8th RMMS	6th RMMS [Only source]	7th RMMS [only source]
Netherlands	8th RMMS	7th RMMS [inconsistent values]	UIC (2020) [only source]	8th RMMS	7th RMMS	7th RMMS	8th RMMS
Poland	8th RMMS	NS [Inconistant definitions and values]	RTO [up to date]	8th RMMS	8th RMMS	8th RMMS	8th RMMS
Portugal	NS[Inconsistent values]	8th RMMS	IRG (2020)	8th RMMS	8th RMMS	8th RMMS	8th RMMS
Romania	8th RMMS	8th RMMS	IRG (2020)	8th RMMS	8th RMMS	8th RMMS	8th RMMS
Slovakia	NS [Inconsistent values]	8th RMMS	IRG (2020)	NS [Inconistant values]	7th RMMS [Only source]	NS [inconsistent values]	8th RMMS
Slovenia	8th RMMS	NS [Inconistant definitions and values]	IRG (2020)	8th RMMS	8th RMMS	8th RMMS	8th RMMS
Spain	8th RMMS	NS [Inconsistent values]	NS [only source]	NS [Only source]	8th RMMS	8th RMMS	8th RMMS
Sweden	8th RMMS	NS [Inconistant definitions and values]	IRG (2020)	8th RMMS	8th RMMS	8th RMMS	No public information available

Source: The Consortium. Note: NS are the national Network Statements; RAMG is the German "Railway Market Analysis" 2019, available here; IRG (2020) is "Overview of Charges and Charging principles for Freight Terminals", available here; IRG (20202019) is "An overview of charges and charging principles for passenger stations", available here; UIC (2020) is "2020 Report on Combined Transport", available here; RTO is the Polish "Railway Transport Office", the report is available here.

Based on the sources listed above, Table 65 below reports the number of service facilities per MS.

Table 65: Number of service facilities by country

Country	Passenger stations	Freight terminals	Intermodal terminals	Marshalling yards[472]	Maintenance facilities	Maritime and inland ports	Refuelling facilities
Austria	1315	16	18	98	37	4	36
Belgium	555	47	49	1	46	120	12
Bulgaria	297	10	1	1	35	14	18
Croatia	537	6	15	1	5	13	16

[472] The very high average distance of marshalling yards in Belgium, Bulgaria, France, and Netherlands is due to the low number of facilities in these countries (respectively 1, 1, 5, and 1). This is probably due to a change in the definition of facilities over the years, as France went from 505 marshalling yards in the 5th RMMS report of 2016 to just 5 in the 6th and 7th report.

Czech	2617	17	18	28	66	4	58
Denmark	454	4	11	18	16	8	20
Estonia	106	42	7				
Finland	531	1	19	18	15	18	33
France	2967	182	45	5	200	11	74
Germany	7033	400	203	66	378	151	420
Greece	352	93	7	5	12	4	11
Hungary	1497	24	23	20	29	8	35
Ireland	145	7	7		2	3	0
Italy	2304	201	98	30	162	23	12
Latvia	132	0		17	17	8	9
Lithuania	131	2	2	74	13		6
Luxembourg	68	1	2	1	1	1	1
Netherlands	399	74	30	1	12	37	15
Poland	2711	415	43	19	219	18	20
Portugal	556	18	2	12	17	10	11
Romania	675	23	20	33	103	131	38
Slovakia	927	26	10	14	26	2	34
Slovenia	269	128	5	1	12	1	9
Spain	1493	93	40	38	25	27	22
Sweden	2034	57	27	13	39	36	

Source: The Consortium

Annex 14 Additional tables and figures on rail infrastructure and rolling stock

Essential service facilities and access to these services.

Table 66: average normalised distance of service facilities, excluding ports

Country	Average normalised distance (excluding ports)
Austria	0.04
Belgium	0.20
Bulgaria	0.47
Croatia	0.25
Czech republic	0.07
Denmark	0.04
Estonia	0.02
Finland	0.13
France	0.35
Germany	0.04
Greece	0.09

Hungary	0.11
Ireland	0.53
Italy	0.29
Latvia	0.04
Lithuania	0.12
Luxembourg	0.10
Netherlands	0.22
Poland	0.23
Portugal	0.13
Romania	0.09
Slovakia	0.05
Slovenia	0.08
Spain	0.31
Sweden	0.15

Source: The Consortium

Table 67: Volume of freight (millions of tkm) of selected goods categories transported via inland transport solutions, 2009-2019[473]

Country	Mode	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Bulgaria	Rail	1,162	1,208	1,445	1,134	1,501	1,629	1,561	1,328	1,359	1,512	1,564
	Road	11,492	11,676	12,295	11,320	11,448	11,861	11,856	10,767	10,094	9,283	8,692
	IWW	3,017	3,564	2,649	3,407	3,186	3,453	4,042	3,886	3,438	2,903	3,795
	Total	15,671	16,448	16,389	15,861	16,135	16,943	17,459	15,981	14,891	13,698	14,051
FRANCE	Rail	13,299	12,823	13,865	12,182	13,132	13,228	13,593	13,255	12,843	11,825	10,434
	Road	51,327	54,888	54,601	50,303	50,072	49,313	46,483	48,080	51,792	52,317	52,980
	IWW	3,997	4,427	4,009	3,863	4,241	4,215	4,138	3,604	3,222	3,280	3,606
	Total	68,623	72,138	72,475	66,348	67,445	66,756	64,214	64,939	67,857	67,422	67,020
HUNGARY	Rail	2,760	2,782	2,757	2,929	4,310	4,026	3,968	4,377	5,582	4,525	4,151
	Road	11,492	11,676	12,295	11,320	11,448	11,861	11,856	10,767	10,094	9,283	8,692
	IWW	989	1,222	1,064	1,106	1,056	986	1,069	1,123	1,166	882	1,202
	Total	15,241	15,680	16,116	15,355	16,814	16,873	16,893	16,267	16,842	14,690	14,045
Ireland	Rail	7	18	23	14	17	17	21	16	17	15	16

[473] In order to avoid the possible confounding effect of COVID-19 on freight transport, the Consortium has opted to limit the analysis to the year 2019.

	Road	2,224	2,107	2,272	2,159	2,090	2,103	2,189	2,471	2,587	2,234	2,664
	IWW	57	106	71	64	42	39	48	69	62	34	68
	Total	2,288	2,231	2,366	2,237	2,149	2,159	2,258	2,556	2,666	2,283	2,748

Source: The Consortium, based on Eurostat, variables 'rail_go_grpgood', 'road_go_ta_tg' and 'iww_go_atygo'. Note: the observations are obtained by summing the annual freight of the categories reported in footnote 69

Access to rolling stock as a barrier to entry and expansion.

Table 68: NVR's data analysis

France		
Rolling stock	**Average age at time of the analysis**	**Estimated useful life**
Freight wagons		
Wagons with opening roof and rigid axles	52 (3)	45
Covered wagons with rigid axles	40 (30)	34
Flat wagons with rigid axles	42 (6012)	43
Open high-sided wagons with rigid axles	55 (232)	41
Tank wagons with rigid axles	57 (43)	46
Wagons with controlled temperature and rigid axles	0 ()	44
Special wagons with rigid axles	58 (4011)	52
Wagons with opening roof and bogies	21 (3546)	38
Covered wagons with bogies	46 (923)	40
Flat wagons with bogies	36 (17978)	40
Open high-sided wagons with bogies	36 (5288)	41
Tank wagons with bogies	31 (11595)	43
Wagons with controlled temperature and bogies	49 (82)	43
Special wagons with bogies	49 (17335)	45
Passenger rolling stock		
Passenger vehicles for domestic traffic, <160 km/h	42 (3038)	
Passenger vehicles for domestic traffic, >160 km/h	44 (811)	36
Night transport passenger vehicles, <160 km/h	72 (123)	35
Night transport passenger vehicles, >160 km/h	56 (1)	
Service passenger vehicles, <160 km/h	46 (301)	

Service passenger vehicles, >160 km/h	42 (81)	36
Service night transport passenger vehicles, <160 km/h	54 (1)	38
Air-conditioned night transport passenger vehicles, <160 km/h	9 (19)	35
Tractive rolling stock		
Miscellaneous locomotives	9 (19)	
Electric locomotives	9 (447)	
Diesel locomotives	30 (1073)	44
Electric multiple-units	29 (1329)	51
Diesel multiple-units	17 (19195)	29
Locomotives with specialised trailer	25 (1434)	42
Diesel shunting locomotives	41 (228)	36
Special locomotives	36 (647)	49

Germany		
Rolling stock	**Average age at time of the analysis**	**Estimated useful life**
Freight wagons		
Wagons with opening roof and rigid axles	69 (507)	50
Covered wagons with rigid axles	31 (10894)	36
Flat wagons with rigid axles	26 (11728)	43
Open high-sided wagons with rigid axles	52 (1793)	27
Tank wagons with rigid axles	42 (1239)	41
Wagons with controlled temperature and rigid axles	79 (3)	
Special wagons with rigid axles	75 (447)	71
Wagons with opening roof and bogies	28 (8184)	37
Covered wagons with bogies	31 (6635)	34
Flat wagons with bogies	25 (60925)	36
Open high-sided wagons with bogies	32 (23860)	30
Tank wagons with bogies	23 (40813)	41
Special wagons with bogies	28 (4537)	37
Passenger rolling stock		

Passenger vehicles for domestic traffic, <160 km/h	29 (3415)	38
Passenger vehicles for domestic traffic, >160 km/h	47 (496)	39
Night transport passenger vehicles, <160 km/h	32 (487)	41
Night transport passenger vehicles, >160 km/h	54 (2)	
Service passenger vehicles, <160 km/h	54 (148)	43
Service passenger vehicles, >160 km/h	40 (1290)	38
Service night transport passenger vehicles, <160 km/h	21 (24)	
Air-conditioned passenger vehicles, >160 km/h	19 (83)	21
Air-conditioned night transport passenger vehicles, <160 km/h	94 (936)	95
Air-conditioned night transport passenger vehicles, >160 km/h	49 (5)	
Tractive rolling stock		
Miscellaneous locomotives	20 (3669)	94
Electric locomotives	33 (1583)	37
Diesel locomotives	13 (14417)	41
Electric multiple-units	23 (5875)	28
Diesel multiple-units	83 (47)	26
Electric shunting locomotives	51 (1996)	44
Diesel shunting locomotives	20 (4346)	49
Special locomotives	20 (3669)	31
Italy		
Rolling stock	**Average age at time of the analysis**	**Estimated useful life**
Freight wagons		
Wagons with opening roof and rigid axles	28 (121)	29
Covered wagons with rigid axles	31 (1905)	27
Flat wagons with rigid axles	43 (1575)	32
Open high-sided wagons with rigid axles	59 (76)	51
Tank wagons with rigid axles	80 (2)	40
Wagons with controlled temperature and rigid axles	74 (1)	51
Special wagons with rigid axles	58 (98)	59

Wagons with opening roof and bogies	34 (798)	31
Covered wagons with bogies	33 (1077)	35
Flat wagons with bogies	34 (7176)	36
Open high-sided wagons with bogies	33 (1837)	32
Special wagons with bogies	43 (711)	42
Passenger rolling stock		
Passenger vehicles for domestic traffic, <160 km/h	34 (4612)	37
Passenger vehicles for domestic traffic, >160 km/h	37 (114)	36
Night transport passenger vehicles, <160 km/h	105 (4)	
Service passenger vehicles, <160 km/h	44 (270)	33
Service passenger vehicles, >160 km/h	34 (1276)	30
Air-conditioned passenger vehicles, >160 km/h	31 (16)	23
Tractive rolling stock		
Miscellaneous locomotives	25 (747)	96
Electric locomotives	22 (1767)	39
Diesel locomotives	36 (372)	40
Electric multiple-units	13 (6830)	39
Diesel multiple-units	25 (1651)	44
Diesel shunting locomotives	40 (339)	43
Special locomotives	19 (272)	
Poland		
Rolling stock	**Average age at time of the analysis**	**Estimated useful life**
Freight wagons		
Wagons with opening roof and rigid axles	44 (226)	
Covered wagons with rigid axles	29 (449)	33
Flat wagons with rigid axles	32 (463)	36
Open high-sided wagons with rigid axles	47 (1447)	46
Tank wagons with rigid axles	51 (31)	54
Special wagons with rigid axles	48 (1832)	48
Wagons with opening roof and bogies	35 (1373)	

Covered wagons with bogies	47 (573)	45
Flat wagons with bogies	31 (11579)	41
Open high-sided wagons with bogies	34 (49566)	36
Tank wagons with bogies	38 (7897)	43
Special wagons with bogies	45 (3429)	52
Passenger rolling stock		
Passenger vehicles for domestic traffic, <160 km/h	39 (2261)	38
Night transport passenger vehicles, <160 km/h	33 (119)	29
Service passenger vehicles, <160 km/h	31 (253)	
Service passenger vehicles, >160 km/h	17 (199)	
Air-conditioned night transport passenger vehicles, <160 km/h	26 (34)	
Tractive rolling stock		
Miscellaneous locomotives	15 (34)	
Electric locomotives	37 (1957)	41
Diesel locomotives	42 (1172)	45
Electric multiple-units	25 (3915)	43
Diesel multiple-units	15 (446)	
Diesel shunting locomotives	46 (856)	51
Special locomotives	39 (3612)	45
Slovakia		
Rolling stock	**Average age at time of the analysis**	**Estimated useful life**
Freight wagons		
Wagons with opening roof and rigid axles	43 (1144)	46
Covered wagons with rigid axles	37 (555)	36
Flat wagons with rigid axles	17 (720)	45
Open high-sided wagons with rigid axles	47 (320)	33
Tank wagons with rigid axles	58 (1)	63
Special wagons with rigid axles	52 (42)	31
Wagons with opening roof and bogies	39 (72)	44
Covered wagons with bogies	25 (449)	38

Flat wagons with bogies	29 (6773)	47
Open high-sided wagons with bogies	35 (13775)	29
Tank wagons with bogies	30 (3712)	40
Special wagons with bogies	39 (1248)	45
Passenger rolling stock		
Passenger vehicles for domestic traffic, <160 km/h	39 (354)	40
Night transport passenger vehicles, <160 km/h	78 (67)	38
Night transport passenger vehicles, >160 km/h	80 (1)	
Service passenger vehicles, <160 km/h	22 (652)	61
Service passenger vehicles, >160 km/h	25 (12)	
Tractive rolling stock		
Miscellaneous locomotives	69 (53)	
Electric locomotives	39 (438)	50
Diesel locomotives	37 (506)	46
Electric multiple-units	14 (206)	45
Diesel multiple-units	17 (217)	20
Locomotives with specialised trailer	20 (146)	38
Electric shunting locomotives	34 (34)	42
Diesel shunting locomotives	42 (106)	58
Special locomotives	38 (861)	42
Spain		
Rolling stock	**Average age at time of the analysis**	**Estimated useful life**
Freight wagons		
Covered wagons with rigid axles	44 (812)	17
Flat wagons with rigid axles	38 (5079)	23
Open high-sided wagons with rigid axles	46 (321)	30
Tank wagons with rigid axles	54 (8)	30
Special wagons with rigid axles	44 (597)	25
Wagons with opening roof and bogies	46 (432)	19
Covered wagons with bogies	36 (537)	12
Flat wagons with bogies	40 (5617)	17

Open high-sided wagons with bogies	39 (3243)	17
Tank wagons with bogies	37 (681)	23
Special wagons with bogies	40 (1122)	23
Passenger rolling stock		
Passenger vehicles for domestic traffic, <160 km/h	42 (684)	33
Passenger vehicles for domestic traffic, >160 km/h	37 (5)	
Night transport passenger vehicles, <160 km/h	33 (26)	
Service passenger vehicles, <160 km/h	82 (94)	95
Service passenger vehicles, >160 km/h	57 (4)	
Service night transport passenger vehicles, <160 km/h	25 (642)	4
Service night transport passenger vehicles, >160 km/h	18 (5)	
Tractive rolling stock		
Miscellaneous locomotives	25 (2181)	11
Electric locomotives	14 (22)	
Diesel locomotives	25 (1646)	25
Electric multiple-units	28 (587)	33
Diesel multiple-units	45 (884)	54
Locomotives with specialised trailer	27 (2491)	10
Electric shunting locomotives	21 (186)	12
Diesel shunting locomotives	45 (254)	23
Special locomotives	28 (581)	17

Source: The Consortium, based on NVR's data. Note: number in parentheses represent the number of observations. No useful life could be computed for categories of rolling stock without a withdrawal mode equal to 33 and 34.

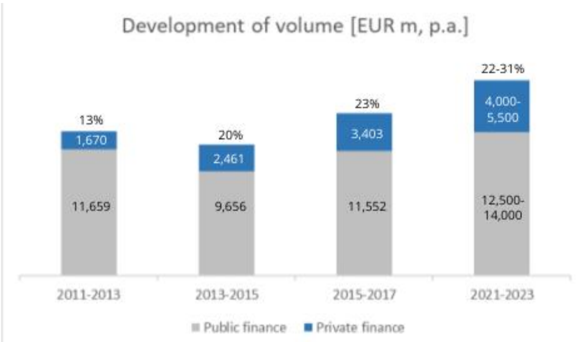
Access to rolling stock

Figure 45: Average age of freight wagons

Source: The Consortium, based on NVR data.

Condition of existing rolling stock

Figure 46: Source of financing of rolling stock projects



Source: Roland Berger (2019).

Table 69: Major projects in Western Europe

Project by	Country	Project description	Eur m	Privately financed*
ERA	GBR	AT300 Trains	543	fully
SNCF	FRA	TGV Trains	480	-
Eurostar	GBR	Velaro Trains	390	partially
RENFE	ESP	Talgo Avril	337	-

Trenitalia	ITA	Pendolino Trains	255	-
RENFE	ESP	Talgo Avril	243	-
NTV	ITA	Pendolino Trains	230	predominantly
First Group	GBR	AT300 Trains	225	fully
First Group	GBR	AT300 Trains	158	fully
NTV	ITA	Pendolino Trains	125	predominantly

Source: Roland Berger (2019) Note: "Predominantly" refers to private financing share of more than 50%; "partially" to less or equal to 50%. Empty cells refer instead to full public financing.

Adequacy of existing rail infrastructure

Table 70: Average area in km2 between facilities, per country

COUNTRY	PASSENGER STATIONS	FREIGHT TERMINALS	INTERMODAL TERMINALS	MARSHALLING YARDS	MAINTENANCE FACILITIES	MARITIME AND INLAND PORTS	REFUELLING FACILITIES	AVERAGE NORMALISED DISTANCE
AUSTRIA	64	5242	4660	856	2267	20968	2330	0.10
BELGIUM	55	650	623	30528	664	254	2544	0.06
BULGARIA	373	11088	110879	110879	3168	7920	6160	0.46
CROATIA	105	9432	3773	56594	11319	4353	3537	0.19
CZECH REPUBLIC	30	4639	4382	2817	1195	19717	1360	0.08
DENMARK	95	10774	3918	2394	2693	5387	2155	0.05
ESTONIA	427	1077	6461					0.05
FINLAND	637	338145	17797	18786	22543	18786	10247	0.33
FRANCE	217	3537	14307	128760	3219	58527	8700	0.50
GERMANY	51	893	1759	5409	945	2364	850	0.02
GREECE	375	1419	18851	26391	10996	32989	11996	0.34
HUNGARY	62	3876	4045	4651	3208	11629	2658	0.08
IRELAND	485	10039	10039		35137	23424		0.49
ITALY	131	1499	3075	10045	1860	13102	25112	0.27
LATVIA	489			3799	3799	8074	7177	0.13
LITHUANIA	498	32650	32650	882	5023		10883	0.21
LUXEMBOURG	38	2586	1293	2586	2586	2586	2586	0.04

NETHERLANDS	104	561	1385	41543	3462	1123	2770	0.10
POLAND	115	753	7272	16457	1428	17371	15634	0.22
PORTUGAL	166	5123	46106	7684	5424	9221	8383	0.21
ROMANIA	353	10365	11920	7224	2314	1820	6273	0.09
SLOVAKIA	53	1886	4904	3503	1886	24518	1442	0.11
SLOVENIA	75	158	4055	20273	1689	20273	2253	0.12
SPAIN	338	5434	12634	13299	20215	18717	22971	0.40
SWEDEN	221	7900	16678	34638	11546	12508		0.23

Source: The Consortium, based on multiple sources (see Annex 13). Note: at this stage, data for storage sidings, other technical facilities, and relief facilities is not available.

Annex 15 Case study: Bettembourg Intermodal Terminal

The Intermodal Terminal Bettembourg is an intermodal hub based in Bettembourg, Luxembourg. It is Luxembourg's only rail to road intermodal hub. It is located on rail freight corridor 2 (North Sea- Mediterranean) and is at the cross roads of the North-South and East-West transport routes.[474] It serves several of the main industrial regions in Europe and has connections to North Sea and Mediterranean ports. It consists of one rail to road intercontinental terminal operated by CFL Terminals. CFL Terminals is part of the same group as the historic train operator CFL though it is a distinct legal entity and, as an open access terminal, works with other train operators. The terminal track facilities can handle up to 12 intermodal container trains (vertical transshipment) and 16 horizontally transhipped rail to motorway trains carrying semi-trailers (rail motorway) a day and has a maximum capacity of 600 ITU per year.[475] But these maximum capacities are conditioned upon increasing the number of cranes. A summary of the terminal's functionality can be found in Table 71 below.

Table 71: Intermodal Terminal Bettembourg: terminal functionality

Modes Served	**Road, Rail, RoLa**
Terminal Operator	CFL Terminals
Total Terminal Area	330,000 m2
Handlings per Year	600,000 Max Capacity 200,000 Handlings in 2018
Handling of	Container Swap Body Semitrailer
Gantry Cranes	2 Gantry Cranes (piggy back)476

[474] See CFL Terminals Brouchure (2021) for more information. Available at: https://www.cfl-mm.lu/getattachment/0d4824be-9325-4694-8c55-5e2497807f3a/term_brochure_210x280_en_08-2021.pdf.
[475] See https://www.cfl-mm.lu/en-gb/solutions/infrastructure/terminal-intermodal for more information.
[476] Note that CFL's terminals website states that they are currently installing a third gantry crane.

Reach Stackers	2 Reach Stackers (piggy back)
Rails	4 x 700 m (Combined railway) 2 x 700 m (Rail motorway Platforms) Total number of tracks: 6 Total usable length: 4,200 m
Reachstackers	3 units/ 15 handlings per hour
Interim Storage	Capacity 2,250 TEU[477] Including: -72 TEU dangerous goods storage area. -24 TEU Reefer (refrigerated container) Storage area

Source: Intermodal-terminals.eu, and CFL website.

An annotated satellite image of the terminal has been included below to provide a visual aid for the size of the terminal and its larger ancillary components. As Figure 47 shows, in addition to the main intermodal terminal, the terminal features an international marshalling yard, logistics park and a secured truck stop. The terminal and its gantry cranes can be seen at the bottom left of the picture. The marshalling yard can be seen in the middle of the picture, a logistics park can be seen to the right and a secured truck stop can be seen to the top left. See Figure 48 for the location of the terminal.

Figure 47: Satellite Image of Intermodal Terminal Bettembourg

Source: Google Earth.

[477] Note that this is stated as 3,425 TEU on the company's website and 2,250 TEU on Intermodal-terminals.

Figure 48: Intermodal Terminal Bettembourg, CFL Terminals, Geographic Location

Source: Google Maps.

According to their website, intermodal terminal Bettembourg operates 8 direct connections with a maximum of 113 trains per week. Direct connections are available to 5 European Union Member States (Belgium, France, Germany, Italy, Poland). Onward sea ferry connections are then available to Denmark, Ireland, Latvia, Sweden, and the United Kingdom. The United Kingdom does not provide substantial incoming traffic. CFL operates 7 out of 8 of the direct connections itself with the Bettembourg – Le Boulou route being operated by a third party.

The third party route to Le Boulou, has the most trains per week and operates up to 51 services a week. Le Boulou is situated in southern France, approximately 10 miles from the Spanish border. The route with the most trains per week which CFL operates is the route to Trieste, which operates up to 24 services a week. Trieste is a sea port in northern Italy with important sea ferry routes to Turkey. The connections have been summarised in the following table:

Table 72: Intermodal Terminal Bettembourg, routes and trains per week

Route	Trains per week
Bettembourg- Antwerp	3
Antwerp - Bettembourg	3
Bettembourg – Valenton	1
Valenton - Bettembourg	1
Bettembourg – Le Boulou	25 12 (Container), 13 (Craneable and Non Craneable Semi-Trailers)

Le Boulou - Bettembourg	26 13 (Container), 13 (Craneable and Non Craneable Semi-Trailers)
Bettembourg – Lyon	6
Lyon - Bettembourg	6
Bettembourg - Trieste	12
Triete - Bettembourg	12
Bettembourg - Poznan	4
Poznan - Bettembourg	4
Bettembourg – Rostock	3
Rostock - Bettembourg	3
Bettembourg - Kiel	3
Kiel - Bettembourg	3

Source: The Consortium elaboration based upon data available through CFL's website.

The terminal was heavily discussed in two state aid decisions[478]. In 2014, SA.38229 established operating aid for Intermodal traffic in Luxembourg that uses Intermodal terminal Bettembourg, estimated at €0.0824/tkm for national rail combined intermodal transport operators[479], SA51613 extended this decision until the 31st of December 2022.

Eurostat data on the share of rail transport in surface freight transport suggests that this scheme may have achieved its objective in incentivising a modal shift to more environmentally friendly forms of freight transport as Luxembourg's share of rail freight as a proportion on surface freight transport increased slightly between 2014 and 2019 from 6.1% to 6.9% as can be seen in the table below whilst conversely the share of road traffic decreased slightly 85.5% to 85.0% although these may seem like small shifts, the shift is more significant you consider on average the percentage share of rail freight by Member State decreased by 2.1% between 2014-2019. Furthermore, prior to the scheme being introduced Luxembourg's share of rail freight as a proportion of surface freight transport decreased significantly from 10.5% in 2011 to 6.1% in 2014. The terminal considers that most of the units it is handling were previously on the road.

The COVID-19 pandemic had a substantial effect on volumes. Weekly trains went down to about 66 per week in 2020 and then ranged between 45 and 90 during 2021, in a highly uneven demand environment according to information received from the terminal.

The terminal features not only vertical crane technology but also horizontal proprietory transshipment technology. It is one of a handful of multi-modal terminals in Europe with this horizontal transshipment technology, others being notably in France and Poland. The terminal is able to reduce time for loading and unloading due to the horizontal transshipment technology.

Table 73: Modal split of freight traffic in Luxembourg 2011-2020

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020

[478] See SA.38229 Luxembourg Aid for the promotion of combined transport for the period 2015-2018, and SA.51613: Luxembourg Extension of the scheme in favour of combined transport in Luxembourg.
[479] See recital 37, SA.38229 Luxembourg Aid for the promotion of combined transport for the period 2015-2018.

Inland Waterways	11.1	8.9	10.5	8.4	8.0	6.2	6.2	7.5	8.2	8.2
Railways	10.5	7.1	7.3	6.1	7.1	6.5	6.8	8.1	6.9	6.6
Road	78.4	84.0	82.2	85.5	84.9	87.3	87.0	84.4	85.0	85.1

Source: Eurostat: Modal split of freight transport dataset (tran_hv_frmod) Last update: 20/04/22.

Annex 15.1 **Profitability of the terminal and drivers of revenues and costs**

The terminal itself does not operate trains. The highest volume of the merchandise through Bettembourg terminal is transported door to door from Poland to Spain.

As an open access terminal, three rail operators use the terminal on a regular basis. One of the transport operators is the affiliated CFL intermodal, with both CFL intermodal and CFL terminals both being part of the Luxembourg national rail operator. The other two operator are operated by Via and LorryRail (to Belou).

Since the entry in service of the terminal in 2017, it has substantially increased through-put and is operating at about breakeven level. The terminal reported that profitability could only improve with more volume and higher efficiencies. Reaching breakeven within 5 years has been an important achievement. The semi automatisation of the cranes and the addition of more cranes would increase capacity, as the main constraint on volume is currently related to cranes, so more would be needed in 5 to 7 years. The current volume of 4-5 trains per day could increase to 16 in and out technically, or 32 trains per day, with more cranes. Any greater increase would require additional rail capacity and yard investment.

Without the public funding, this investment would not have been undertaken and the facility that existed would instead have been that using 1970s infrastructure. This facility was not built to modern standards and would have reduced intermodal capacities com-pared to the current and future potentials. Due in large part to its 1979 core technology, intermodal traffic using that previous terminal fell, and the terminal suggested that the rail share of Luxembourg freight declined from 10.5 per cent in 2011 to 6.5 per cent in 2016 because of the old infrastructure in the years before the beginning of this new terminal. The new terminal is much more efficient and adaptable. One can expect, and the management of CFL Tterminals believes, that intermodal activity would be lower without this new terminal. While it is hard to say how low, the prior trend before its opening would suggest the rail share could have fallen even further after 2016. The terminal receives no operational support. At least one of the rail operators has received operational support.

Revenues at CFL Terminals are primarily related to movement of freight, but also include storage, certification, a gas station, a speed repair lane and other services. The primary source of revenue is thus handling and the secondary source is storage. The operation of the gas station is subcontracted.

Costs are primarily related to labour costs and to equipment. These costs can be further divided into fixed and variable costs. Most costs are fixed, while energy costs are clearly variable.

Annex 15.2 **Future expected demand and planned investments**

The future demand is increasing and management expects that to increase substantially as a result of broader EU initiatives. In order to achieve the predicted substantial in-creases in volume, large system investment will be required, particularly on rail infra-structure outside the intermodal terminals. The rail system as a whole will need to be able to handle longer, heavier and more frequent trains. The infrastructure between terminals will in particular need upgrading to handle this increase in demand. The impacts of upgrading would follow through on reliability, speed and frequency.

While rail access costs may affect transporter decisions on whether to use rail transport compared to, e.g., road, the management considered that the cost of ensuring that locomotives can drive in different countries is also large but not so obvious. Rail has many hidden costs.

The management of the facility felt that selective terminal investment more generally is required to meet the future demand. The CFL terminals' previous investment in horizontal technology could be more useful if other terminals more generally adopt such technology. CFL tTerminals now has 15 years of experience with the technology. While they have now proved its worth to them, many partners remain to invest in this technology. The technology is most efficient when used at both ends of transport. As a result, the rollout of the technology may be subject to market failure, to the extent that the system benefits are greater than individual terminal benefits, though this remains to establish. Broader installation of this technology may require that terminals receive outside support to install it initially. In the long run horizontal loading will reduce loading and unloading time, and thus help to address one of the main reasons for transporters opting against rail.

The terminal has reached the point at which new crane investments are needed. Cranes serve as a scalable bottleneck, while the track infrastructure in place at the terminal is sufficient to handle greater volume.

The terminal is exploring future investments and will need to keep up to date with any future changes in power technology.

Locomotives are not actually owned by CFL terminals. Tractors are. Like many terminals, CFL tTerminals is considering future investments in battery-powered terminal tractors. One disadvantage of such technologies is that they can have an increase in initial cost of about 2/3 compared to a diesel tractor. To their advantage, they have much lower maintenance costs and the technology will be cleaner.

If hydrogen becomes a major fuel for trains, a delivery and storage system would need to be installed for this new fuel.

Annex 15.3 **Main findings**

This terminal is one of the few in Europe currently operating with horizontal loading technology. According to the terminal, broader investment in this type of technology could potentially increase overall speed of movement across modes and enhance the intermodal transition.

The commercial case for these new rizontal loading technologies may require state support, even if the technologies themselves have lower operating costs than current ones, as current assets are not yet expired in their value and life.

The experience of the terminal suggests that state support can make a positive difference to intermodal outcomes, as volume at the 1970s intermodal facility were falling prior to new investment that created this terminal. The investment inverted the tendency from one of shrinking intermodal traffic and a new growth for intermodal traffic.

Annex 16 Case study: METRANS Hub in Prague

Annex 16.1 **Overview of the terminal**

METRANS, established in 1991, is a RU active in intermodal freight transport, which is vertically integrated as it also operates 19 intermodal terminals across Central and Eastern Europe, allowing it to serve all major European seaports. The METRANS terminals are located in the Czech Republic, Hungary, Slovakia, Poland, Austria, and Germany. The case study focuses on the rail-road intermodal terminal located in Prague, in the central-western part of the Czech Republic, at the heart of the Bohemian region, and was initially built to connect the Port of Hamburg with the Czech Republic. The terminal is the first that has been built and operated by METRANS. Figure 49: Satelite image of the METRANS Hub in PragueFigure 49 shows a satellite image of the terminal.

Figure 49: Satelite image of the METRANS Hub in Prague

Source: Google earth.

The Hub in Prague is the largest terminal operated by METRANS, extending over an area of 420,000m^2, of which 270,000m^2 are dedicated to the temporary stacking of containers. The terminal also offers a total of 7.4km of rail tracks, divided among seven sidings of 600m, two sidings of 550m, and six sidings of 350m. The rail tracks are served by seven automated rail-mounted gantry cranes, used for loading and unloading intermodal units, running 24/7 all days of the year. This allows the terminal to handle up to 10 trains simultaneously. Given its strategic location at the heart of central Europe, the METRANS Hub in Prague serves as an agglomeration point for freight arriving from smaller terminals. At the Hub in Prague, long inbound trains coming from both within the EU and Asia are dismantled, and the cargo is redistributed, bundled, and dispatched for further rail transport into the European hinterlands. Although the lion share of the freight that passes through the terminal is handled directly by METRANS, METRANS has stated that access is granted in a non-discriminatory manner to all licensed RU and freight transport operators in line with Directive 2012/34/EU. To these operators, METRANS provides also complementary services such as weighting, storage, and maintenance of containers, in order to support its position as a one-stop intermodal terminal.

Yard operations are backed by a variety of high-capacity equipment, including three reach stackers that can handle up to 45 tonnes, 10 reach stackers for lighter units (up to 10-12 tonnes), and two forklifts that can handle 16 tonnes each. Within the terminal, train movements are handled by four shunting locomotives, two of which are hybrid electric catenary/battery, which according to METRANS allows to cut CO^2 emissions by over 50% compared to diesel shunters. The Terminal Hub in Prague also offers a storage capacity of 10,000 TEU for empty containers, and of 15,000 TEU for filled containers.

Table 74 below summarises the infrastructure available at the METRANS Hub in Prague.

Table 74: METRANS Hub in Prague area and infrastructure

DESCRIPTION	
420,000	m2 of area
270,000	m2 of stacking area
7.4	Kms of rail tracks
6	Rail mounted gantry cranes
3	45t Reachstackers
10	10/12t Reachstakers
2	16t Forklifts
10,000	TEU depot capacity for empty containers
15,000	TEU depot capacity for filled containers
4	Shunters

Source: The Consortium based on METRANS' website accessible here.

Figure 50 below shows the geographical location of the METRANS Hub in the Prague within the European Union.

Figure 50: METRANS Hub in Prague geographic location

Source: Google Maps.

Annex 16.2 **Profitability of the terminal and drivers of revenues and costs**

Working as an agglomeration hub, the Hub in Prague allows METRANS to serve all countries in the European Union. Table 75 below summarises the main connections operated through the Hub in Prague; the terminal offers a link with major European seaports such as Rotterdam (Netherlands), Hamburg, and Bremerhaven (Germany). Moreover, the Hub in Prague has a daily connection to the terminal located in Ceska Trebova (Czech Republic), which is connected to all the other METRANS terminals, which are themselves connected to other intermodal terminals in Europe. In addition, the Ceska Trebova hub links the Hub in Prague to the Belt and Road initiative[480] by connecting it to Malaszewice (Poland) and Dobra (Slovakia), the main entry point to the freight coming from China.

Table 75: Direct connections to the METRANS Hub in Prague

Origin	Destination	trains per week
Origin	Destination	trains per week
Hamburg	Praha	54
Bremerhaven	Praha	13

[480] The Belt and Road Initiative "aims to promote the connectivity of Asian, European and African continents and their adjacent seas, establish and strengthen partnerships among the countries along the Belt and Road, set up all-dimensional, multi-tiered and composite connectivity networks, and realize diversified, independent, balanced and sustainable development in these countries", see Belt and Road Initiative.

Rotterdam	Praha	10
Duisburg	Praha	6
Praha	Ceska Trebova	28
Praha	Salzburg	10
Praha	Leipzig	1
Total		122

Source: The Consortium based on METRANS' group presentation, accessible here.

In order to provide its customers with intermodal freight transport solutions, multiple operations take place at the Hub in Prague. For instance, when the train arrives, it gets shunted at the shunting station, and then it gets moved to the terminal where the wagons are positioned under the cranes. The containers are then unloaded from the train and loaded onto the trucks. While METRANS does not perceive the speed to execute these operations as a measure of the performance of the terminal, and thus does not collect precise statistics on this, it estimates that around 60 minutes are usually required for the whole process. The METRANS' management consider this time frame to be relatively short, and that the Hub is Prague is therefore quite efficient in its operations.

At the terminal, together with the handling of the containers, complementary services are also offered; these services are somewhat of a bundle, as they are necessary to ensure that the cargo can be handled (for instance, storage is a necessary complementary service, as usually it is not possible to unload a train and directly load the intermodal unit onto a truck; similarly, maintenance of a container might be necessary before the container is loaded on a freight wagon), and therefore the terminal cannot provide specific figures regarding the profitability of each service offered by itself. Nonetheless, the largest share of revenues stems from the handling of containers, which makes the terminal profitable; indeed, the METRANS Hub in Prague is trying to operate at around a 5-8.5% profit margin per year. METRANS' management believes that, even if one were to look at the single services provided by themselves, they would all still be profitable, although, the storage of containers could potentially be loss making, but it is necessary to offer such a service to ensure the operability of the terminal.

Before the COVID-19 outbreak, the amount of freight handled at the Hub in Prague was growing by around 3% per year. The pandemic has caused a disruption in the supply chain, leading to lower growth rates and also to a change in the type of freight handled at the terminal. For instance, the lockdown in China has been associated with a drop of about 10% in maritime and non-maritime freight handled within Europe in the second quarter of 2020. Nonetheless, METRANS's management has explained that the Hub in Prague has managed not only to recover, but also to slightly improve on the levels reached before the COVID-19 outbreak. Nowadays, the terminal handles on average a daily inbound and outbound traffic of around 300-400 trucks and 20 trains. As a result, according to METRANS, the terminal ranks first across all CEE countries, with a throughput capacity of approximately 600,000 TEU/year, rivalling even bigger terminals in Germany and other Western European countries.

METRANS' management has explained that most of the operations at the Hub in Prague are automated. For instance, the weighing of the containers is performed automatically through the cranes and the railway gates are 100% automated using the optical character reading of the container railway car. Nonetheless, some operations still need to be handled by the staff. Indeed, the technical situation of the containers needs to be checked manually, and current regulation requires that also the seal needs to be checked when a container is sealed. Consequently, it can be estimated that approximately 70% of the overall process for handling of the containers at the Hub in Prague is automated. The reason underlying the high level of investment in the automation of processes is the improvement of the terminal's productivity, which makes the processing of containers easier and faster, and although it has not reduced neither the costs nor the staff employed at the terminal, it has proven to be effective in increasing its profitability.

The high level of automation of the terminal can explain its flexible cost structure, compared to more traditional terminals. METRANS' management has explained that the main cost items for the Hub in Prague are investments and staff, which represent approximately two thirds of the total costs. Investments costs include cranes (around 45 million Euros each) and reach stackers (around 400-500 thousand Euros), as well as in the automation of processes. The technology of reach stackers requires also investment in high-pressure ground surface (100 megapascals of pressure are required to handle 100 tons of freight using reach stackers). Moreover, a highly trained staff is needed in order to connect the terminal to the road. As these costs would be incurred in even if the terminal would stop operating for a period, they can be considered fixed. The remaining share of the costs, approximately one third, is related to the fuel and energy that is needed to operate the cranes and vehicles within the terminal. This is a cost item that is strictly related to the volume of freight moved, thus it is a variable cost, which is the main reason why the cost structure of the METRANS Hub in Prague can be described as relatively flexible.

Annex 16.3 **Future expected demand and planned investments**

The METRANS Hub in Prague serves as a service point for the agglomeration of freight coming from different routes which, METRANS' management has stated, has being growing at a steady rate over the past. Moreover, there is still enough spare capacity at the terminal to sustain the additional growth in the volume of rail freight moved which would allow to reach the goal of doubling the rail modal share by 2050. Therefore, no investment is currently planned to increase the rail capacity of the terminal.

Nonetheless, METRANS considers that the goal is not achievable by the EU.

Indeed, according to METRANS' management, there are no bottlenecks in the value chain at the level of intermodal terminals, neither in terms of number of terminals nor capacity. As the market for intermodal terminals is very competitive, if there was more demand for the services provided, new terminals would be built, or existing terminals could be expanded with relative ease. Instead, a bottleneck exists at the level of rail freight transport due to the existing railway network in the EU, which lacks the capacity to handle more trains and, thus, cannot sustain the planned increase in freight traffic. For instance, METRANS has reported that they have been trying to introduce a new connection for the past 4 months, but they are yet to reach an agreement with the infrastructure manager, as it has not been possible to fit this new connection into the existing infrastructure's schedule. Indeed, the time to introduce a new connection act as a disincentive to shift freight transport away from road, as the road connections can be set up in a matter of days, and not months, thus providing it with a competitive advantage.

Moreover, the existing infrastructure is not considered adequate also because it does not allow to operate longer trains (for instance, because sidings are too short), which would be pivotal to foster a modal shift as they would allow to increase the productivity of the train and reduce the costs of the rail leg, making it more competitive compared to road haulage.

Moreover, METRANS has explained that in their view, it is the whole European infrastructure that is lacking, and not just a single country. For instance, the German infrastructure manager (DB Netz AG) has suggested that METRANS may need to revise its development plans, since the current infrastructure does not have the capacity to handle the expected growth in freight moved. METRANS believes that only in Austria, which it considers to be the most efficient country in terms of handling the rail traffic and planned investment for the expansion of the infrastructure, it would be possible to handle the increased amount of freight. In addition, METRANS's management has stated that it does not believe that the EU is doing what is necessary to support the modal shift, and that European policies have not been enough to reach even just 10% of the investment that would be needed to double rail freight transport by 2050.

According to METRANS, the EU needs to focus its investment agenda on the basic infrastructure (i.e., rail tracks), not on terminals or on building highways and parking lots for trucks, that give further incentives rely on road transport rather than rail transport, if it wants to foster a modal shift. Countries such as the Czech Republic and Hungary are considered to have no capacity to handle the cargo on rail, regardless of the current situation in their terminals.

Another issue pointed out by the METRANS management is the cost related to accessing the infrastructure: METRANS is often forced to reroute its freight trains through Austria and Germany, because the track access charges are lower in these countries, which allow to reduce the costs even if the rail length becomes longer; indeed, they estimate that the overall cost of the rail leg can be reduced by about 10% simply by rerouting the trains, whereas passing through other EU MS would increase the operating costs to a level that would hardly make rail competitive.

Annex 16.4 **Impact and pass-through of state support measures**

METRANS has not been the recipient of State aid for at least the past 10 years. Nonetheless, METRANS has explained that from their point of view, European funds for intermodal transport, for instance the Connecting Europe Facility fund but also other EU measures as well as measures at the MS level, is not always seen as efficient in achieving the modal shift to rail for two reasons. First, the support is often targeted at freight terminals, but having high-quality terminals without a matching high-quality railway infrastructure would lead to under-utilisation of the intermodal terminals; second, according to METRANS, the funds to freight terminals are awarded without any clear rules, which leads to a distortion of competition in the market. Terminals are a competitive business (capable of being financed from private sources, when there is a sufficient demand for such services), and thus having State aid that distorts competition crowds out private investments.

METRANS considers that, if the European Union is interested in promoting the modal shift, support should be allocated in such a way that makes the rail leg of the journey cheaper and more competitive compared to the road leg, instead of funding intermodal terminal. For instance, following the recent rise in electricity prices, rail freight transport has become less attractive in terms of cost compared to road transport; providing funds to reduce the energy costs could make rail competitive again. Nonetheless, the current situation suggests that there is no optimistic prospect when it comes to energy for the next five to 10 years. Therefore, METRANS believes that Europe needs a precise regulation to set the cost of rail transport at the same level of road transport in terms of train*kilometres and trucks*kilometres, or possibly even lower, if it wants rail to become competitive enough to ensure a modal shift.

Annex 16.5 **Clean technologies**

METRANS operates mostly electric locomotives, both as a RU and as a shunting operator within its terminals. The management has explained that electric locomotives require both a higher initial investment and a higher expenditure for maintenance and repair compared to diesel engines, due to the more complex nature of the tractive technology which leads to more frequent malfunctioning of certain components. Nonetheless, the higher investment and maintenance costs are compensated by higher tractive power, which allows to move longer and heavier trains and, thus, increase the productivity level of a train, and usually also by lower prices of energy, which in normal times can be estimated to be at least 30% lower than diesel.

Recently, Slovakia, the Czech Republic, and Hungary have witnessed an increase in the costs of electricity, which METRANS estimates to be about 100%, 75%, and 300-500%, respectively. For this reason, they have switched to diesel locomotives in Hungary, which reduced their traction costs by approximately 20-25%.

Annex 16.6 **Main findings**

The METRANS HUB in Prague has a relatively flexible cost structure. Staff and investment represent around 2/3 of the annual costs, and these can be considered fixed costs. The remainder of the costs is represented by the fuel and energy used to operate the cranes, which varies with the volume of freight moved. This structure is the result of METRANS high investments in the automation of freight handling processes, aimed at improving the terminal's productivity by making intermodal operations faster. The cranes, the gates and the weighting system are fully controlled by computers; as a result, approximately 70% of the loading and unloading process inside terminals does not require staff. The remaining operations, such as custom checks and integrity of the containers check-ups, are performed manually because of the regulation requirements. This high level of automation has affected the cost structure of the terminal, making it more flexible than other intermodal terminals in Europe.

Services offered at the terminal are considered to be profitable: overall, the profit margin on total revenues is around 8.5%. The main source of revenues is the handling (i.e., the loading and unloading) of intermodal units. The remaining revenue comes from the complementary services provided. Some services are provided as a bundle (for instance, once a container has been unloaded it needs to be stored until it can be loaded on a different train or on a truck), and so it would not be correct to look at these services by themselves. Nonetheless, if one where to look into it, the provision of storage services might be loss making, although it is impossible to not offer the service at an intermodal terminal.

The management of the terminal considers that the METRANS Hub in Prague has sufficient spare capacity to handle any increase in freight traffic that might be needed to reach the goal of doubling the rail modal share by 2050; indeed, intermodal terminals are very competitive, and shall the need for more capacity arise it would be possible to build new terminals. Nonetheless, the goal of doubling the rail modal share is considered unachievable because of the inadequacy of the existing railway infrastructure. According to METRANS, the current infrastructure is congested, which means that not only it is impossible to increase the number of trains operating on the European network (for instance, METRANS has been trying for months to introduce a new rail connection, but it has found difficulties in adjusting to the existing train schedule to get access to the main railway network), but also to increase the length of the trains; indeed, longer trains would allow to reduce the costs of the rail leg, thus increasing its competitiveness and favouring a modal shift. Instead, the congestion of the current infrastructure is such that METRANS has been suggested to revise its growth plans, as an infrastructure manager has stated that they would not be able to handle the increase in traffic.

Another issue pointed out by the METRANS management is the cost related to accessing the infrastructure: METRANS is often forced to reroute its freight trains through Austria and Germany, because the track access charges are lower in these countries, which allow to reduce the costs even if the rail length becomes longer; indeed, they estimate that the overall cost of the rail leg can be reduced by about 10% simply by rerouting the trains, whereas passing through other EU MS would increase the operating costs to a level that would hardly make rail competitive.

Finally, METRANS describes the current Connecting Europe Facility fund as inadequate to foster the modal shift in Europe. METRANS considers the market to be very competitive, but the funds that are provided to specific terminal operators across Europe distort competition and do not foster the modal shift to rail, as they do not lead to a reduction in the costs of the rail leg compared to other modalities. To increase rail competitiveness, the European Union should focus its investment on the railway infrastructure, to allow for more frequent, longer and heavier trains to be operated, instead of providing funds to intermodal terminals.

Annex 17 Case study: Port of Duisburg

DIT Duisburg Intermodal Terminal is a trimodal terminal (rail, road and inland waterway) situated within the situated port of Duisburg, Germany. The port of Duisburg is considered the largest inland waterway port in world[481]. Initially opened in 2002, the terminal offers barges services to the Netherlands (Rotterdam, Amsterdam), Belgium (Antwerp and Zeebrugge) and Germany and more than 50 rail connections to Belgium, Hungary, Russia, the Czech Republic, Austria, Germany, Italy and ongoing connections to China. The terminals key characteristics have been summarised below:

Table 76: Intermodal Terminal DIT Duisburg GmbH: terminal functionality

Modes Served	Road, Rail, Barge
Terminal Operator	DIT Duisburg Intermodal Terminal GmbH
Total Terminal Area	120000 m2
Handling of	Containers
Rails	6 x 750m Total Number of Track: 6 Total Usable Length 4500m
Gantry Cranes	RMG (Rail Mounted Gantry cranes) Rail: 2 x 50 t / 30 handlings per hour Barge: 1 x 50 t5 / 30 handlings per hour
Reach Stackers	1 unit / 15 handlings per hour
Interim Storage	Capacity: 7500 TEU
Services	Container Maintenance Container Repair Dangerous Goods Reefer
Other Services	Stuffing / Stripping

Source: Intermodal-terminals.eu: https://www.intermodal-terminals.eu/database/terminal/view/id/83.

3D rendered google earth image of the intermodal terminal below shows its position on the Rhine, it's gantry cranes, quay and railway tracks can also be made out. Below this a google maps imagine shows the terminals geographic position within the European Union.

[481] See CCNR: Central Commission for the Navigation of the Rhine, Annual Report 2020. 'Inland waterway traffic in ports'. See: Inland waterway traffic in ports - CCNR - Observation Du Marché (inland-navigation-market.org), last accessed on the 3th May 2022.

Annex 17.1 Profitability of the terminal and drivers of revenues and costs

The terminal is an important tri-modal terminal, due to its strategic road, rail and Rhine access. It considers itself "the perfectly organised gateway to the Benelux seaports with rail connections to Southern Europe".[482] It also play a key role in Contargo, an integrated operator of 22 hinterland terminals in Europe, with an annual throughput exceeding 2 million TEU and EUR 566 million, also a member of Rhenus Group, itself a subsidiary of privately held Rethmann Group.

It has inland waterway connections to Rotterdam, Antwerp and Amsterdam. In addition, it has rail connections to Rotterdam, Antwerp and Zeebrugge. These connections should not be considered as direct substitutes, as the waterway connections may help in terms of slower movement and just-in-time traffic management. Additional rail connections go to Austria, Bulgaria, China, Italy, Poland, Russia, Turkey, Czech Republic, and Hungary.

The frequency and nature of its different types of connection are shown in Connections from DIT Duisburg

Table 77: Connections from DIT Duisburg

Connections	Frequency per week	Place
Inland Waterway	3-5	Rotterdam
Inland Waterway	3-5	Antwerp
Inland Waterway	1	Amsterdam / Zeebrugge
Rail	10-12	Rotterdam
Rail	5	Antwerp
Rail	1	Zeebrugge
Extra rail connections		Austria, Bulgaria, China, Italy, Poland, Russia, Turkey, Czech Republic, Hungary

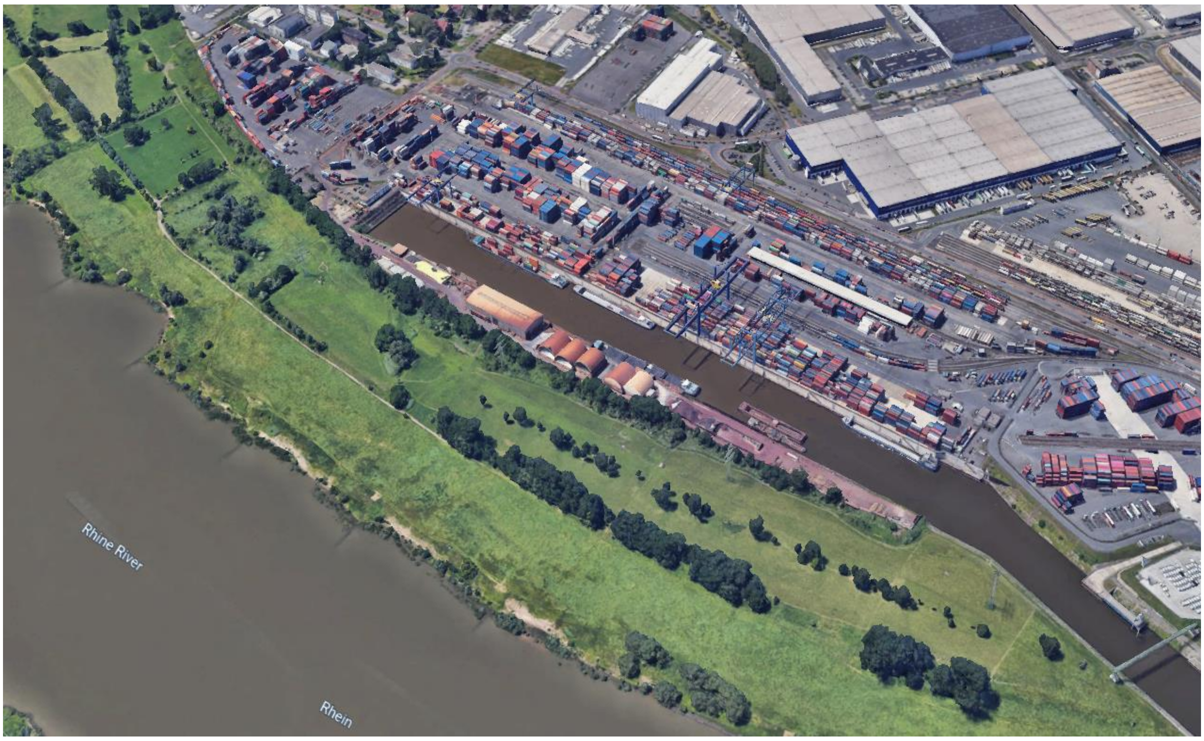
Source: Contargo.net, https://www.contargo.net/en/terminals/duisburg/#facts.

The Duisburg terminal can serve as a key connection to China. On 2 February, 2021, Contargo unloaded about 40 40-foot containers that had arrived in Duisburg from China. The barge used by Contargo has a capacity of 104 TEU under normal depth conditions and thus creates a path for cargo from China that cuts 20 days from the normal sea route time. The use of container barges of this size requires that both origin and receiving terminal be equipped properly to handle such barges.

Containers from China arrive in Duisburg by about 30 trains per week, helping to implement the New Silk Road path from China to Western Europe.

[482] See https://www.contargo.net/en/terminals/duisburg/#about, accessed 22 August 2022.

Figure 51: Google Earth 3D Rendered Image of DIT Duisburg Intermodal Terminal GmBh



Source: Google Earth.

Figure 52: DIT Duisburg Intermodal Terminal Gmbh – Geographic Location

Source: Google Maps.

Specific information on the profitability of individual facilities is not individually released. The ultimate owner is Rethmann Group with 72,000 employees, EUR 14.4 billion in revenues and EUR 3 billion in equity.[483]

Eurostat data on the share of rail transport in surface freight transport in Germany is shown in Table 78. Over this ten-year period there has been a notable shift away from inland waterways and rail to road transport.

Table 78: Modal Split of Freight Traffic in Germany 2011-2020

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Inland Waterways	9.4	10.1	10.2	9.9	9.1	8.7	8.7	7.5	8.0	7.4
Railways	19.3	19.1	19.1	18.8	19.3	20.2	18.5	18.9	18.7	17.6
Road	71.3	70.8	70.7	71.3	71.6	71.2	72.8	73.6	73.4	75.0

Source: Eurostat: Modal split of freight transport dataset "tran_hv_frmod". Last update: 20/04/22.

Annex 17.2 **Investment, state support and clean technologies**

During the summer of 2022, the site has experienced critically low levels of the Rhine and its tributaries over an extended period. 2018 was also a critical period for low water levels. This low water levels reduced movement capacity on the Rhine and created a shortage for barge-based movement of freight, including via containers, which were forced to compete with coal and grain for the limited space.

On 7 June 2022, Rhenus Trucking and Contango received funding approvals for 28 battery-driven 44-tonners. These trucks will be put in service at terminals of the Contargo. The company stated that "Intermodal transport with a range of up to 250 km per day between the terminal and the customer is an ideal use for these vehicles."[484] The funding provided will include support for charging infrastructure such as battery storage, transformers, energy management systems and the work necessary to put these in place.

Annex 17.3 **Main findings**

The main findings of this case are that the facilities access around multimodal terminals are key for good operating conditions of the terminal. Many of these conditions can be influenced by state activity and state decisions. During 2022, frequent closures of train lines due to construction and cancellation of trains, along with low water levels and long waits prior to permission to dock and unload in Rotterdam and Antwerp. In 2018 low water levels had substantial impacts on traffic.

The company is making substantial investments for electrification that have received state support. At the same time, its integrated structure allows for more guaranteed profitability from joint investments at multiple facilities, such as for bringing high capacity container barges from Duisburg to Valenciennes. More generally, the company seeks "reliable framework conditions"[485] from policymakers that will permit long-term investments consistent with sustainability objectives.

[483] See https://www.transdev.com/en/press-release/rethmann-group-intends-to-acquire-the-veolia-stake-in-transdevs-capital-and-will-support-transdevs-development-alongside-caisse-des-depots-group/.
[484] See https://www.contargo.net/en/pressreleases/2022-06-08_foerderbescheid/
[485] See https://www.contargo.net/en/infodownload/.

Annex 18 Case study: Port of Budapest

According to the company's website the Mahart Container Centre in the Freeport of Scepel, (south-southeast of Budapest on the river Danube), is the dominant container terminal in Hungary.

The terminal dates back to 1969 and by 1998 had 39,000m2 of storage space. It began a further series of large-scale improvements in 2006 and by 2018 had a container loading capacity of 175,000 TEU / year[486]. Traffic at the terminal has increased steadily over the past few years from 218,851 TEU in 2017 to 411,447 TEU in 2020[487]. A summary of the terminal's functionality and a satellite image of the terminal can be found in Table 79 and Figure 53 below. The terminals geographic location is displayed in Figure 54.

Table 79: MAHART Container Centre Ltd: terminal functionality

Modes Served	Road, Rail, Barge
Terminal Operator	MAHART Container Centre Ltd
Total Terminal Area	110000 m2
Handling of	Container Swap Body Semitrailer
Rails	2 x 690 m 3 x 300 m Total number of tracks: 5 Total usable length: 2120 m
Loading Shoreline	220m
Gantry Cranes	1 x 30 t
Reach Stackers	6 x 45 t / 15 handlings per hour 3 x 11 t / 15 handlings per hour 15 handlings per hour
Interim Storage	Interim Storage Capacity: 7100 TEU
Services	Security Customs Container Maintenance Container Repair Container Cleaning Dangerous Goods Reefer Trucking
Other Services	Trimodal (road-rail-barge) solutions - Handling of reefer containers, - Handling of hazardous containers

[486] See https://containercenter.hu/bemutatkozas/eszkozok/index.php for more infomation.
[487] See https://containercenter.hu/bemutatkozas/forgalmi_adatok/index.php.

- Depot for empty containers,
- Container examination,
- Flexi-tank, inliner, thermoliner fitting, Customs services, Stuffing & stripping services.

Source: The Consortium elaboration using data from Intermodal-terminals.eu: https://www.intermodal-terminals.eu/database/terminal/view/id/273 and MAHART Container Centre website: https://www.containercenter.hu/ and direct feedback.

Annex 18.1 Profitability of the terminal and drivers of revenues and costs

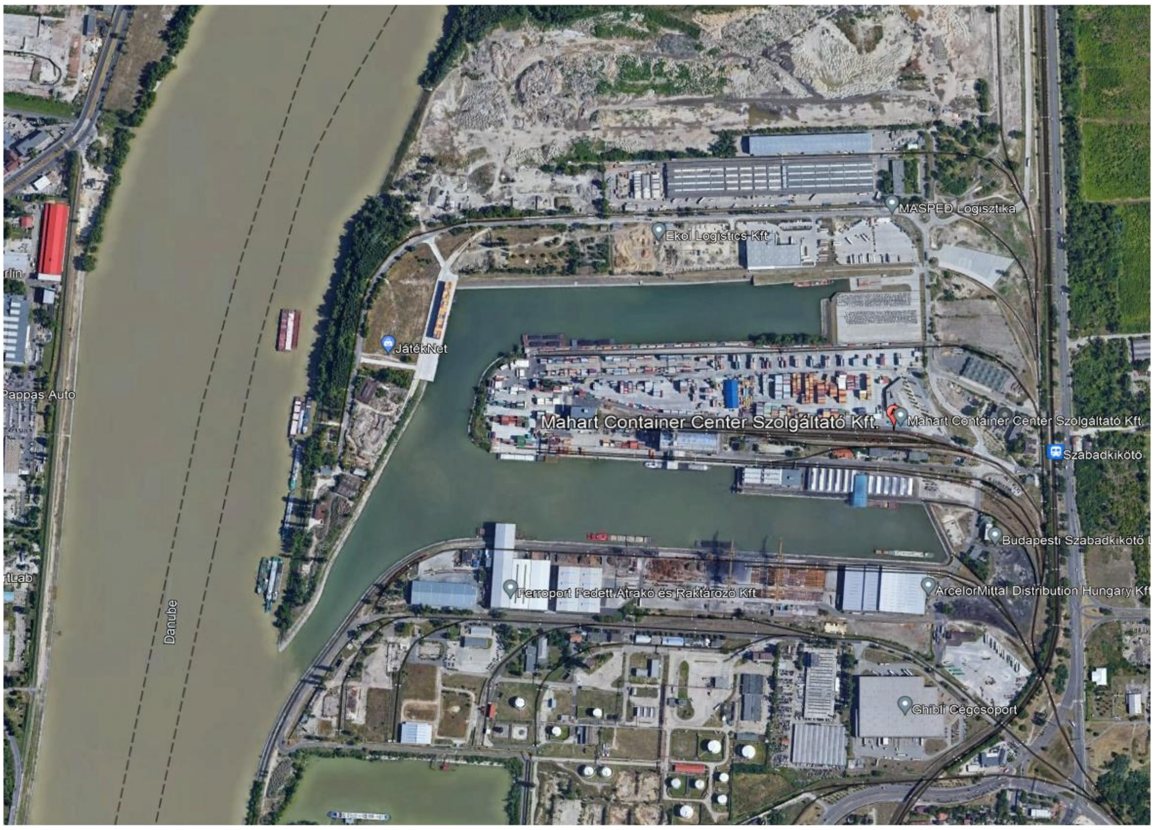
Mahart Container Centre's operations include trimodal road-rail-water loading of containers and other intermodal transport consignments, and storage of containers. The terminal offers services that include handling, storage, repairs, transshipment, reefer plugs, weighing, clearance, transport organisation, and shunting. The main sources of revenue of the terminal are handling of containers, serving as a depot for empty containers, storage of containers, container repair, trans-shipment and other services like organisation of transport and shunting.

The theoretical maximum TEU/year that could be handled is 260,000, while the practical maximum is 230,000. Over the three years from 2019-2021, realised movements were about 217,400 TEU/year. While the tonnes moved depends on the weight of the containers, in 2021, 3.5 million tonnes were moved. The maximum daily inbound and outbound trucks of 135,000 per year and inbound/outbound daily trains of 2,400 (theoretical) per year, with daily truck movements over 2019-2021 of 135,000 over a year and actual inbound/outbound daily trains over a year of 2169. This suggests that, in particular for truck handling, the terminal is operating at the maximum of its current capacity.

The terminal has a cost structure that is primarily built up of material costs (including energy), bought-in services, staff costs, depreciation and taxes and dues. Of these, the equipment, building, long-term rental (concession) of the area would be considered fixed costs. Variable costs would include staff, energy, repair materials, and bought-in services.

In the case of the MAHART terminal, multiple intermodal operations are possible. While road/rail constitutes the majority of volume, road/inland waterway constitutes 4 per cent of total volume. In terms of time for processing, containers on a barge are take twice the time of truck/rail containers and semi-trailers to rail are take 1.5 times longer than road/rail containers. The terminal does not handle accompanied transport.

Figure 53: Satellite Image of MAHART Container Centre Ltd



Source: Google Earth.

Figure 54: MAHART Container Centre Ltd – Geographic Locaiton

Source: Google Maps.

A list of train and barge connections is shown in Table 80. The main countries of origin and destination of the freight handled are Germany for continental transport and China and South Korea for maritime hinterland transport. The terminal typically serves 7 – 10 operators over the course of a year.

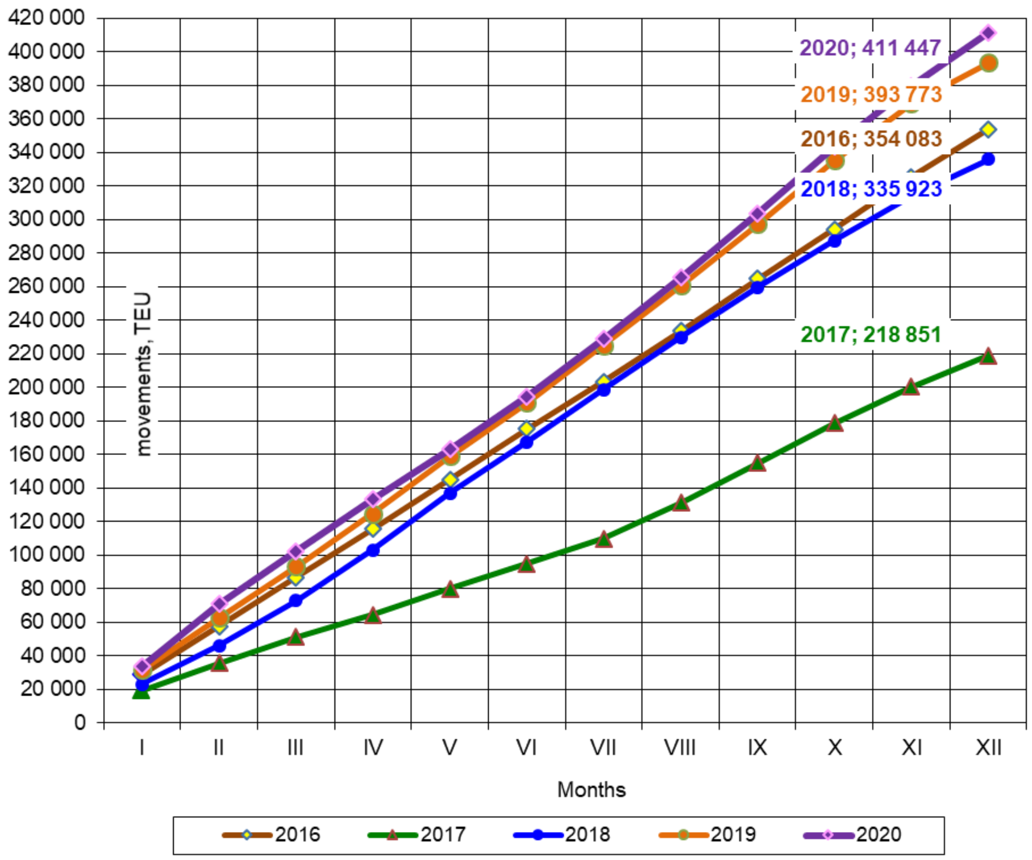
Table 80: Train and Barge connections from Mahart Container Centre

Train connections	Barge connections
Budapest-Bremenhaven **Budapest-Koper** **Budapest-Trieste** **Budapest-Rijeka** **Budapest-Vienna (with connection to Wels, Ludwigshafen, Duisburg, Rotterdam, Antwerp and Hamburg).** **Budapest-Cologne Budapest-Herne Budapest-China via Malaszewicze (PL), Dobra (SK)** **Budapest-Herne** **Budapest-Kína via Malaszewicze (PL), Dobra (SK)**	Budapest-Konstanza (Galac, Belgrade) Budapest-Bratislava (transport on request) Budapest-Regensburg (Vienna, Enns, Linz) Budapest-Konstanza (Galac, Belgrade) Budapest-Bratislava (transport on request) Budapest-Regensburg (Vienna, Enns, Linz)

Source: https://containercenter.hu/szolgaltatasok/terminali_szolgaltatasok/index.php.

The key performance indicators for the site have evolved positively since 2017, as shown in Figure 55.

Figure 55: Movements, TEU 2017-2020



Source: MAHART.

Recent years have included one that was profit negative, in 2017, due to the loss of a key customer. This situation was addressed through business acquisition rather than investment or divestment. Currently, the terminal covers its costs. The terminal does not offer services at prices that are structurally loss-making.

Eurostat data on the share of rail transport in surface freight transport in Hungary is shown in Table 81. There is some year-on year variation of the modal split between road, rail and inland waterways over this ten-year period but no discernible trend away from road over this timescale.

Table 81: Modal Spilt of Freight Traffic in Hungary 2011-2020

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Inland Waterways	5.7	6.4	6.1	5.5	5.4	5.4	4.8	4.1	5.2	5.0
Railways	28.5	29.8	30.7	31.1	29.5	28.6	32.4	27.0	26.3	29.1
Road	65.8	63.8	63.3	63.4	65.1	66.1	62.7	68.9	68.5	65.9

Source: Eurostat: Modal split of freight transport dataset "tran_hv_frmod". Last update: 20/04/22.

There is one State aid decision that is relevant: SA.37402 (2013/N) titled 'The intermodal development of the Freeport of Budapest' which concerns the provision of funding for investments to enhance the intermodal capabilities, through the upgrading of inland port infrastructure through the construction of connecting roads and rail tracks totalling EUR 11.05 million. Most of this is funding from the Cohesion Fund (EUR 8.69 million) with EUR 1.533 million from national funds and the remainder funded by Mahart.

Annex 18.2 **Future demand and investment**

As the terminal is currently operating at full demonstrated capacity utilisation, no further volume increase is anticipated without a corresponding increase in investment. The difference between theoretical and demonstrated actual capacity is largely due to the unpredictable arrival of trains and delays. Key constraints for any future expansion would include rail transport infrastructure in Hungary, the reliability of rail transport and the navigability of the Danube.

In terms of infrastructure, much construction is on the way, with, for example, a bridge over the Danube.

Planned investments for meeting forecast demand would need to include new electric gantry cranes (a very large investment for the overall size of the company), refurbishment of the concrete surface and IT systems. Terminal expansion is limited by the area.

General investments needed for the future would include investment in rail service quality. Investments in trans-shipping capacity in cranes, even with co-funding of the investment, have consistently been declined by the EU. The terminal finds that green, intermodal transport is held back by such refusals to co-finance.

Annex 18.3 **State support and clean technologies**

To date, the existing state support measures have not included a state subsidy but have included a modest support (under EUR 100k) related to IT investment. This goal underlying this investment has been fully achieved.

This investment allowed for improved train-turn times and consequent improved use of capacity by train operators.

Currently the terminal uses diesel fuelled reach stackers. The terminal would like to replace these with electric gantry cranes. The terminal twice applied for a CEF subsidy grant and was declined both times.

In terms of operating costs of the desired technologies, they would exhibit a 40% saving on repair and maintenance and a 60% saving on fuel costs. Furthermore, using gantry cranes would also increase throughput capacity, providing opportunity for further increase in intermodal transport and shifting traffic from road to rail and water. Despite these savings, the economic case for making a new investment while existing technology can do the job has not been compelling for the operator.

Annex 18.4 **Main findings**

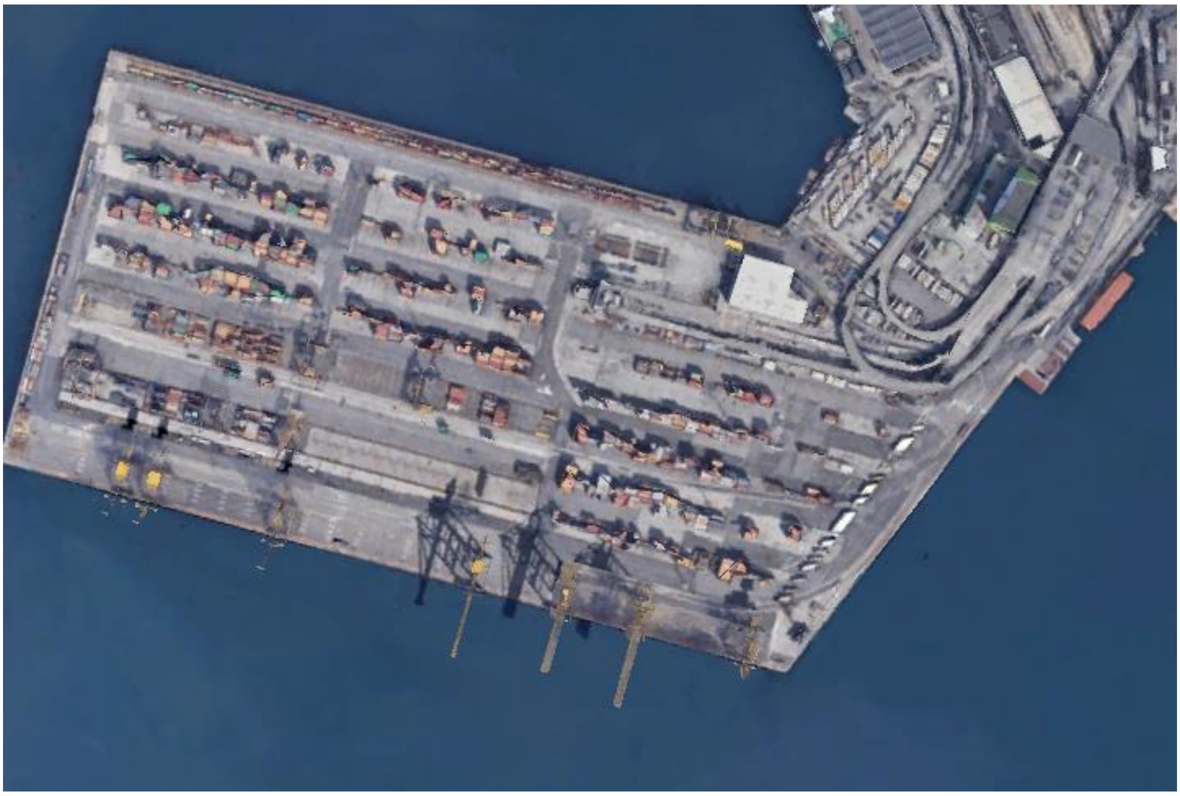
The main findings from the case study are that successful intermodal facilities can reach their maximum capacity utilisation and still face investment constraints for expanding to increase capacity. State support does not always step in to help the investment case for desirable new investments even when these would increase the efficiency of operation and increase the capacity of an intermodal terminal. The breadth of state support needed to increase intermodal traffic is not limited to the terminals but also extends to the infrastructure that interacts with the intermodal terminals. Rail service quality and waterway navigability also would be recommended as a key area of focus to enhance the output of this intermodal terminal.

Annex 19 Case study: Trieste Marine Terminal

Annex 19.1 **Overview of the terminal**

The Trieste Marine Terminal (TMT) is located within the port of Trieste in Northern Italy, on the coasts of the Adriatic Sea, close to the Slovenian border. TMT offers rail, road and sea intermodal solutions to connect Central and Eastern European countries. Due to the lack of locks, bridges and tidal restrictions, Trieste is one of the safest ports in the Mediterranean area; the favourable climate conditions of the zone protect the port from the risk of fog, which would lead to a slowdown of the operations. Figure 56 shows a satelite image of the terminal.

Figure 56: Satelite image of Trieste Marine Terminal



Source: Google earth.

TMT extends over a 400,000 m^2 area, including 2,500 m^2 of covered storage area and another 2,500 m^2 of uncovered storage. The terminal is built on stilts, which implies that any future expansion of the terminal needs to be carefully planned. Currently, TMT is equipped with a total of 3 kilometres of rail tracks, divided into 5 tracks of 600 meters; each track is served by 3 rail mounted gantry cranes, able to operate up to 5 trains at the same time, for a total of about 7,000 trains per year; these trains connect the terminal with different cities in Italy, Germany, Hungary, Austria, Slovakia and the Czech Republic.

As a sea terminal, TMT offers both deep and short-sea intermodal freight solutions, thanks to its 770 meters of operational quay, with the deepest natural draft of the whole Mediterranean Sea (around 18 meters at the berth), allowing all kinds of containerships to berth quickly and easily. The quay is equipped with 7 Post Panamax cranes, used to load and unload intermodal containers from container ships. Part of the containers that arrive at TMT via deep sea are then redirected using short sea shipping to terminals located in Venice, Ravenna and Ancona (and other ports upon request), for which TMT acts as a feeder hub. Within the Mediterranean area, TMT has direct connection with Greece, Malta, Cyprus, Turkey, Lebanon and Egypt.

The information on the terminal infrastructure is summarised in Table 82 below.

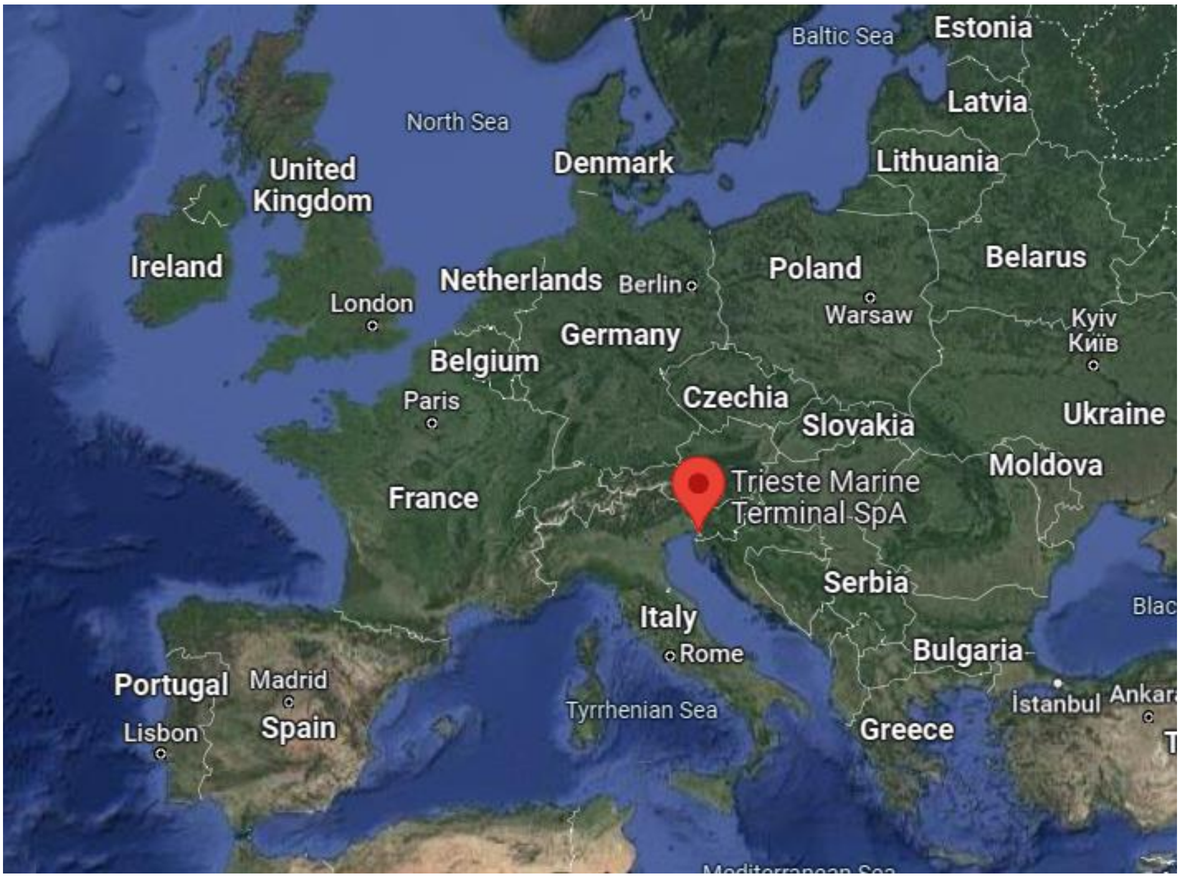
Table 82: Trieste Marine Terminal area and infrastructure

Description	
400,000	m2 of stacking surface
770	Metres of operational berth
600	Metres of supporting berth
18	Metres of natural draft
7	Post Panamax quay cranes
3000	Meters of rail tracks inside the terminal (5 tracks of 600 meters each)
2500	m2 of warehouses (covered)
2500	m2 of warehouses (open area)
405	Integrated reefer points
450	Stacking positions (TEU) for I.M.D.G goods (international Maritime Dangerous Goods)
362	Working days per year 24 h a day, for both marine and rail operations
7	Rail mounted gantry cranes for the Yard
3	Rail mounted gantry cranes for the Rail
47	Trailers (terminal chassis)
18	Reach Stackers
33	Prime movers (terminal tractors)

Source: The Consortium based on publicly available information.

Figure 57 below shows the geographical location of TMT in Europe.

Figure 57: TMT geographical location



Source: Google Maps.

Annex 19.2 Profitability of the terminal and drivers of revenues and costs

During the 1990s, the terminals located within the port of Trieste were privatised. The terminal was initially managed by ECT (which also operates intermodal terminals in various ports in the Netherlands, Germany and Belgium) and then by Port of Koper (Slovenia), but according to TMT current management, the first two administrations did not bring about significant changes to the operative structure of the terminal; in particular, many of the previous employees were retained. This did not lead to satisfactory results for the terminal. It should be noted that the previous management also manages the terminal located at the Port of Koper, which is one of the main competitors of TMT: it is therefore reasonable that it did not have a strong incentive to invest in the development of the port of Trieste, and that from their perspective the TMT represented a backup solution. The current management took over the terminal in 2004 and set up a plan of medium-long term growth through considerable investments in both the infrastructure and internal operational restructuring; indeed, the investments included not only the introduction of state-of-the-art transshipment technologies, but also a change in the personnel and an overall increase in the staff directly employed by the terminal, which grew from 3 people in 2004 to around 240 people nowadays.

Because of these investments and the new operative structure, TMT witnessed a substantial growth in terms of freight moved. Regarding rail traffic, the last few years have been characterised by a steady growth in terms of both number of trains and TEUs handled. Trains handled at TMT increased from 1,637 in 2016 to 3,634 in 2019, with a constant increase of around 900 trains per year on average in that time span, whereas the rail related TEUs increased from 75,000 in 2016 to 200,000 in 2019. More generally, the number of TEU handled by TMT increased from approximately 449,500 in 2016 to approximately 668,600, thus around 48% in just 3 years, and grew by more than 387% compared to 2004, when the terminal handled about 177,600 TEUs.

The numbers presented above, though, are yearly figures. Indeed, there is a seasonality in freight transport that affects also the operations at TMT. In particular, TMT's management has reported that a peak can usually be observed before Christmas, starting from mid-October and ramping up until mid-December, followed by a slowdown which ends with the Epiphany in January. Given its international dimension and the fact that a substantial part of the traffic of the terminal comes from vessels arriving from the Far East, an event that affects TMT's business is the Chinese New Year, which diminishes inbound traffic for around 10 days in February. Finally, in the summer, the 15th of August festivity affects the traffic handled by the terminal, as the Italian portion of the traffic slows down in the second half of August and gets back to regular levels in September. However, the extent to which this affects the overall freight traffic handled by the terminal is limited, given the international relevance of the port of Trieste for freight transport.

TMT's management reports that in the period 2017-2019, before the COVID-19 outbreak, the terminal had witnessed an all-time peak in terms of both quayside (ships) and rail (trains) movements. In 2020, the spread of the pandemic and the resulting lockdowns imposed by national authorities worldwide, caused a significant drop in the TEU moved through the terminal, especially in the first six months. Such reduction was especially relevant for rail movements, which declined by around 25% compared to 2019. With respect to the inbound freight from China, the effects of the lockdowns were delayed due to the long time required by sea travel; indeed, a vessel coming from China requires at least one month to reach Italy, if not more, thus some vessels that departed just before the lockdown reached the port, whereas the lack of departures from Chinese ports was felt with at least one month of delay. Nonetheless, TMT reports that between September and December 2020 the terminal has witnessed a sharp growth, especially of the rail movements but also on the quayside, which allowed to compensate for the reduction observed during the first half of 2020, allowing the terminal to reach the end of 2020 with approximately the same level of traffic handled before COVID-19. For example, on the railway side, among the six months with the highest level of freight moved since 2004, four have been in 2020. While the adverse effects of the pandemic on freight traffic were reduced in 2021, rail traffic was still slightly lower than in 2019, with 190,000 TEU/year compared to 200,000 TEU/year, but in 2021 the volumes of freight moved were more consistent throughout the year, though also in 2021 there was some irregularities due to the obstruction of the Suez Canal that took place between the 23 and 29 of March.

The high level of volumes moved at the terminal ensure that its operation is profitable; TMT profit margin on total revenues has been estimated by the management to be between 5 and 7%. Since 2011, there has never been a year characterised by a loss, although there has been variation in the yearly profit levels. The main source of revenue for the terminal is the handling (i.e., the loading and unloading) of intermodal units that arrive via sea. Indeed, TMT has explained that shipping companies are the only direct clients of the terminal. Around ten shipping companies arrive at Trieste Marine Terminal, though only four or five can be considered large companies (in terms of volumes moved). All other freight transport operators, such as RU and logistics companies, that operate within the terminal, are not direct clients of TMT; every interaction that the terminal has with these companies is due to a contract with the shipping company which has authorised the transshipment of the intermodal units onto the trucks, trains or short-sea vessels.

Even though these are not direct clients of the terminal, TMT has a somewhat clear picture of the set of operators with which the terminal interacts. Truck companies are many, both local and international – from Slovakia, Germany, Croatia; on the other hand, the number of railway companies served is limited, though it is considered adequate by TMT. These operators include Italian ones (Mercitalia, the incumbent, and

Inrail, a smaller operator), Captrain Europe, controlled by the French SNCF, and Austrian operators (Rail Cargo Austria, with which there is a strong and long-lasting relationship, and Eco Rail).

TMT offers also complementary services such as the weighing of the loading unit before it is loaded on a ship, container maintenance, or storage of cargo, but the revenues accrued from these activities account only for a marginal part of the terminal's profitability. Indeed, some of these services are offered just because they are necessary to handle the cargo, but they are not particularly promoted by the terminal, that has instead an incentive to limit the cargo's idle time inside the terminal, as this deprives the terminal from space that could be dedicates to other operations. This is for instance the case for storage services. Another complementary service that has to be offered is the weighing of the intermodal units: international mandatory regulations, indeed, envisage that all containers must have a Verified Gross Mass (VGM) to ensure vessels' stability. The shipper is usually responsible for the VGM; however, it is not always possible for shipping companies to arrange the weighing before the unit gets to the terminal. In this case, the unit is weighed at the terminal before the loading operations.

Among the complementary services offered by the terminal, intermodal connections with specific cities or countries are sometimes offered at a loss, especially in the initial phase. This is for instance the case for the Trieste – Budapest rail connection, which is the main one and operates with a slight loss. This occurs because the main competitor, the Port of Koper, is closer to Budapest, so TMT has to keep its prices at a comparable level to be competitive, and given the higher distance travelled this implies a slight loss. Nonetheless, intermodal services are essential for the terminal, as they allow shipping companies to load and unload their cargo at TMT, and if they were not offered, the volume of freight moved on a yearly basis would drop significantly.

Despite the high investment in infrastructure made by the current management, there is no automation at TMT, and every process requires to be operated or supervised people; for this reason, the cost structure of TMT is quite rigid. TMT's management has explained that the most important cost item is represented by personnel: for instance, every vehicle needs an operator, and the more the operator who handles the vehicle is specialised, the more productive the terminal; the terminal's weighbridge, used to weigh the intermodal units that are loaded at the terminal, also requires to be handled by an operator. Overall, the cost for personnel represents around 50% of the annual costs. Another 40% of the total costs stem from space and infrastructure investments. Both these cost items, which represent together approximately 90% of the annual costs for the terminal, are mostly fixed (e.g., staff needs to be paid whether or not there is freight to move at the terminal). The fuel and electric energy needed to operate the cranes and the vehicles within the terminal represent just about 10% of the total costs and is the only voice that varies with the level of freight moved, thus making the cost structure of TMT very rigid, and with almost no difference between the different intermodal transport solutions.

Annex 19.3 **Future expected demand and planned investments**

Given the current infrastructure, TMT can handle approximately 900,000 TEU/year, but TMT management has explained that a should operate at a level below its maximum capacity (around 80%, which is approximately 720,000 TEU/years; TMT currently handles slightly below 700,000 TEU/year) in order to avoid congestion and bottlenecks due to the contemporaneous movement of too many intermodal units, as the lack of automation does not allow to optimize the reach stackers' path and would hinder the level of productivity of the terminal and its profitability. On average, the terminal currently handles:

- 300 inbound and outbound daily trucks;
- 10 inbound and outbound daily trains; and
- 600 inbound and outbound yearly vessels.

Each unit represents an operation rather than a physical entity. For example, the same train which enters the terminal and leaves with a different load is counted twice, because it is identified through a different code, and might even be managed by a different Railway undertaking.

An investment to further increase capacity has already been planned and approved by local authorities: it consists of a 100x400 metres extension of the berth, which will allow to increase the number of vessels served, and to raise the maximum capacity up to 1.2 million TEU/year. This implies that, if the 80% of capacity handled yearly will be kept, the terminal will be able to handle almost 1 million TEU/year.

TMT expects that demand for freight movement, including rail, will increase in the next years. Indeed, in recent years, TMT has witnessed a modal shift towards rail; while in 2017, for hinterland freight traffic, the rail share was about 41% (against a 59% of freight moved via trucks), this increased to 52.3% in 2019. Modal shares were virtually unchanged in 2021, with rail traffic reaching 53%. The share of rail traffic from and to Italy has increased in 2021 with respect to the previous year, parallel to a reduction in the traffic from and to Germany. The share of traffic from and to Austria, Slovakia, Czech Republic and Hungary has remained fairly constant between 2020 and 2021, with the latter representing the main country in terms of volume of traffic from and to TMT.

While long term projections are difficult to make, TMT's management considers that the EU goal to double the rail freight volumes by 2050 is feasible. Nonetheless, TMT has explained that existing railway network in Europe is a source of concerns for the modal shift. Indeed, from TMT's point of view, there are two fundamental aspects that can incentivize the demand for rail transport. The first is the reliability of the services, and the second is the competitiveness of the service, which is simply the price.

In order to increase the volumes of freight moved by trains, and thus reduce the cost of the rail leg, TMT's management considers that the possibility to handle longer trains would contribute to achieving that goal. For example, Germany's maximum length of trains is 750 meters (max 1,700 tonnes), while the maximum size in Southern Europe is smaller (550 meters, 1,300 tonnes) for geological reasons. Nonetheless, having longer trains, like in the USA (trains' length can reach 1.5 kilometres), would make them more competitive. For example, TMT has two main corridors: one of them connects Trieste to the Austrian border passing through Udine. It would be possible to arrive at the Austrian border with long trains (e.g., 750 meters), but the connection to the Austrian infrastructure is very steep, so a shunting process must be undertaken.

TMT considers that to foster this modal shift it is essential that the railway infrastructure is adequate also to serve the intermodal terminals. Indeed, increasing the number of rail connections between the port of Trieste and other locations allows to attract more freight transport companies, and therefore to increase the number of containers handled by the terminal. As of now, there is a project developed jointly with Rete Ferroviaria Italiana (RFI), with a budget of €180 million, aimed at doubling the current capacity in terms of the number of trains handled at the nearby station of Campo Marzio, thus attracting more freight to the terminal. For the same reason, there is a project to develop a station in Budapest.

Currently, the maximum length of trains at TMT is 550 metres, but TMT's management considers the internal infrastructure to be sufficient to handle longer trains. As there are five tracks of 600 meters, to allow a 750 meters train to operate, it would be sufficient to break it into two tracks. Nonetheless, there are already plans to increase the length of the tracks in the future, but for now the quay investment has priority. Overall, TMT considers that there is enough spare capacity to handle the increase in demand that would be linked to a doubling of the rail modal share, and if needed the terminal could be further expanded. While physical constraints may hamper the extension, as any future expansion has to be towards the sea as the terminal is facing the city from the other side. Indeed, the terminal has been built on stilts, which may represent a further limitation, in that it may imply less capacity per square meter, due to the lower weight that the infrastructure can support. However, technological developments since the terminal was first built make this less of a problem from the point of view of TMT's management.

Annex 19.4 Impact and pass-through of state support measures

TMT's management has stated that the terminal did not receive any substantial State support. National State aids, if any, was marginal.

Annex 19.5 Clean technologies

Electrification of the railway lines within TMT via catenary is not possible, due to the transshipment technologies which are top lifting, and cannot be operated if there is an overhead line. For this reason, while trains that arrive to the close station of Campo Marzio are usually electrified, they need to rely on diesel locomotives in order to enter the terminal.

There is currently a development plan for the station of Campo Marzio, which would allow to operate new hybrid electric catenary/battery locomotives; with these new hybrid locomotives, the battery would be recharged during the main leg of the journey, and then used to enter the terminal, so that catenary lines would not be needed. In this way, the "last mile" of the journey would not require diesel powered locomotives. In any case, TMT's management has explained that the terminal is not directly involved in the management of diesel and electric vehicles, which are outsourced to Rail Cargo Austria even for the intermodal connections offered by the terminal (such as the Trieste – Budapest connection), and therefore it is not in a position to discuss the different costs related to the purchase and operation of electric locomotives compared to diesel ones.

Annex 19.6 Main findings

TMT presents an inflexible cost structure. Staff and investments in the infrastructure represents approximately 50% and 40% of the annual costs, and are mostly fixed, whereas the remaining costs (around 10%) are related to fuel and electricity, and vary depending on the volumes of freight moved. The inflexible cost structure is mostly due to the lack of automation of the terminal, which also plays an important role in the necessity to operate below the maximum capacity and avoid the risk of congestion. Were the processes more automated, the path of the reach stackers used to move the containers within the terminal storage area could be optimised, reducing the risk of congestion and TMT might operate at levels closer to the maximum capacity. Instead, if the terminal exceeded 80% of its maximum capacity, it is likely that bottlenecks would arise, causing a reduction of productivity and, in turn, profitability.

TMT is overall profitable, with a profit margin on total revenues between 5 and 7%. Although there has been some heterogeneity in the levels of profitability during the years, TMT has always been operated with a positive margin since 2011. The main source of revenues is the handling (i.e., loading and unloading) of the intermodal units that arrive via sea. Nonetheless, the terminal also offers ancillary services necessary to handle the cargo, but these are virtually irrelevant in terms of profitability. For instance, the terminal offers the weighing service, container maintenance and storage of cargo. In order to expand its geographical reach, the terminal also offers intermodal services; for instance, it cooperates with Rail Cargo to offer connections between the port of Trieste and Austria, Hungary and Slovakia. Such intermodal services might be offered at a loss, especially in the initial phase; this is the case for the Budapest intermodal connection, which currently operates at a small loss. Nonetheless, these connections are essential to ensure that higher volumes of freight are handled by the terminal.

Before the COVID-19 outbreak, TMT had reached an all-time peak in terms of both ships and trains movements. In 2020 the spread of the pandemic, and the resulting lockdowns, led to a marked reduction in the TEU moved handled, especially in the first six months of the year. Nonetheless, between September and December 2020, TMT witnessed a sharp increase in both the quayside movements and the number of trains. This allowed to compensate for the decrease occurred in the first half of 2020 and, ultimately, to reach yearly levels of traffic comparable to before the pandemic.

Trains that enter the terminal rely on a diesel engine as it is not possible to use electric catenary within the terminal because the transshipment technology is a top lift, which prevents the use of catenary lines. Nonetheless, there are plans to redesign the near station of Campo Marzio, which would allow new hybrid electric catenary/battery locomotives through the station, and to reach the terminal relying on the electricity provided by the battery, which would be recharged during the main leg, thus eliminating the need to rely on diesel engines for this "last mile".

TMT's management considers the goal of doubling the rail modal share of freight traffic by 2050 feasible, as there is enough spare capacity at the terminal. The main would be represented by the railway infrastructure in the EU, which is not apt to deal with longer and heavier trains. For example, TMT has a corridor that connects Trieste to the Austrian border. It would be possible to arrive at the Austrian border with long trains (e.g., 750 meters), but the connection to the Austrian infrastructure is very steep, so a shunting process must be undertaken. Moreover, there is also a heterogeneity in the standards used across different EU MS; while in Germany the maximum length of trains is 750 meters (~1,700 tonnes), in Southern Europe this is just 550 meters (~1,300 tonnes) for geological reasons. These differences represent an issue for the railway sector because they increase handling costs and therefore hinder rail competitiveness.

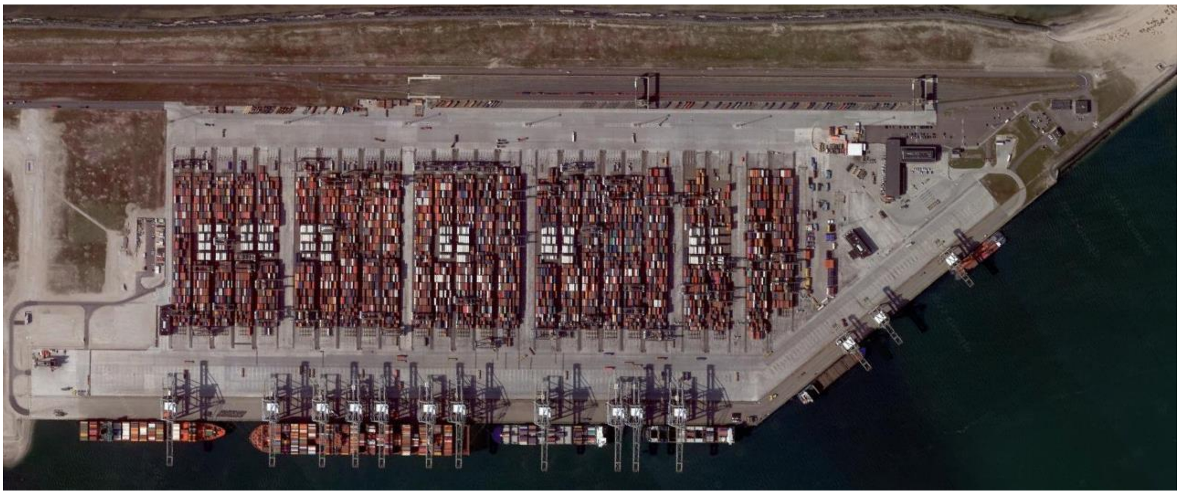
Annex 20 Case study: Rotterdamn World Gateway

Annex 20.1 Overview of the terminal

The Rotterdam World Gateway (RWG) terminal, which has been operative since 2015, is a fully privately held company, and is not controlled by any port authority or public body. There are four international shareholders that own the RWG terminal: DUBAI, CMCGM, HMM, MOL.

The terminal is located on the Second Maasvlakte of the port of Rotterdam, which sits directly on the North Sea, and is approximately 40 kilometres west of Rotterdam; it acts as a gateway to Europe for freight coming via deep-sea vessels from Asian countries and the North Atlantic area, which is then redistributed within the European Union via rail, road, inland waterway barges and short-sea vessels (the RWG's management defines this last modality as "feeder", because the freight does not originate from within the EU; nonetheless, the difference is purely conceptual). Regarding the other freight transport modalities, the terminal handles freight from the Netherlands, Germany and Belgium. Figure 58 shows a satellite image of the terminal.

Figure 58: Satelite image of Rotterdam World Gateway



Source: Google earth.

The terminal is built on reclaimed land and has an area of 1,080,000 m^2. It is divided into five different zones:

- the deepsea quay. It has a length of 1,150 metres and a 20 meters drafts; this is where intercontinental deep-sea vessels arrive, and the containers are unloaded through 13 quay cranes;
- the storage area. It is connected to the deepsea quay by 84 automatic guided vehicles; here the containers are stacked on top of each other by 50 automatic stacking cranes;
- the barge/feeder quay. It has a length of 550 meters and an 11 meters draft; this is where containers are loaded onto inland waterway barges and short-sea vessels through 3 quay cranes;
- the truck handling zone. This is where containers coming from the storage area are loaded onto trucks; the zone has enough space to handle up to 125 trucks simultaneously; and
- the train terminal. It is equipped with 6 tracks of 750 metres, for a total of 4.5 kilometres; this is where the containers coming from the storage area are loaded onto the trains using 2 rail cranes.

The transport between the quay and the storage area is provided through 84 automatically controlled vehicles; once the containers reach the storage area, they are stacked on top of each other by the automatic stacking cranes, where they usually remain for three to four days before being loaded onto other vessels, barges, trucks or trains. According to RWG's management, the terminal is one of the most automated in the world, as the loading and unloading operations are automated for all transport modes except rail (this is due to the layout of the terminal, and the fact that having both automated processes and personnel in one area is considered dangerous, thus limiting the opportunity for partial automation). Moreover, all the information processing has been digitalised in order to provide a faster and more reliable service; intermodal operators need to book their time slot in the terminal, and before reaching the terminal they need to submit all the relevant container information through the port of Rotterdam's online system. This allows RWG to provide real-time operational data, such as the status of the container, container handling time, and vessels arrival and departure times through the RWGServices online portal.

Table 83 below summarises the infrastructure available at the METRANS Hub in Prague.

Table 83: Rotterdam World Gateway's infrastructure

Description	
1,080,000	m2 of area
550	Metres of barge/feeder quay
11	Metres of water depth for barge/feeder services
1,150	Metres of deepsea quay
20	Metres of water depth for deepsea services
6x750	Rail tracks
2	Railcranes
3	Quay cranes
13	Deepsea cranes
50	Automatic stacking cranes
84	Automatic guided vehicles for internal transport
125	Truck handling positions

Source: The Consortium based on RWG's website, available here.

Figure 59 below shows the geographical location of RWG within the European Union.

Figure 59: Rotterdam World Gateway geographic location

Source: Google Maps.

Annex 20.2 **Profitability of the terminal and drivers of revenues and costs**

Most of the inbound freight that arrives at the terminal through deep-sea vessels originates from Asian countries such as China and South Korea, as well as from North and South America. Overall, inbound traffic represents approximately two thirds of the total traffic of the terminal.

Once deep-sea vessels reach the RWG terminal, the intermodal units are unloaded and stored for around two to three days, before being loaded onto trains, trucks, feeders, and barges. As for outbound hinterland transport, 45% of the freight is transported via barges, 20% via trains, and the remaining 35% via trucks. Table 84 below reports the average weekly traffic of the terminal.

Table 84: RWG inbound and outbound weekly traffic

Type of traffic	
300	Inbound and outbound trucks per week
40 to 50	Inbound and outbound trains per week
70 to 80	Inbound and outbound barges and feeders, divided approximately as 30% feeders and 70% barges

8 to 9	Inbound and outbound deep-sea vessels per week

Source: The Consortium based on data provided by RWG.

The feeder network is quite vast. Indeed, the short-sea vessels that depart from the RWG terminal connect the port of Rotterdam with all parts of Europe, from the Black Sea to Scandinavian countries.

The terminal has a capacity of approximately 2,350,000 TEU/year and, according to the terminal's management, RWG is currently operating at full capacity for what concerns deep-sea transport, whereas the terminal could handle approximately 20% more inland and short-sea operations by increasing the number of trains, barges and feeders handled.

Being an almost-completely automated terminal, RWG does not offer complementary services such as shunting and marshalling, containers maintenance, or weighting, which would require to rely on trained staff. It has also been reported that container terminals such as RWG do not generally offer these kinds of services. Temporary storage is offered for a certain number of days, and if it exceeds a specific length of stay a surcharge is applied. Overall, RWG's management reports that the main source of revenues for the terminal remains the handling (i.e., loading and unloading) of intermodal units from the deep-sea vessels. Indeed, only deep-sea shipping lines are direct customers of the RWG terminal; according to RWG's management, there are approximately 10-12 big shipping lines in the world, which are organised into three alliances, of which two are served by the RWG terminal (the Ocean Alliance and THE Alliance). The terminal operations are profitable, and profit margins on total turnover are estimated to be around 10%.

The terminal has no contractual relationship with the other freight transport modalities operators (rail, road, barge, feeders), so precise information on the number of operators active in the market could not be provided, but it is estimated that the terminal serves between 25 and 30 barge operators, 10 railway operators and more than 1,000 trucking companies. As these are not direct clients of the terminal, they are not a direct source of revenue; nonetheless, the handling of the cargo for these modalities, which is reliant on the contract with the shipping lines, contributes to the overall profitability of RWG.

Differently from what has been reported by other terminals, RWG's management has stated that, while COVID-19 has initially caused a small reduction in the inbound freight traffic in the first quarter of 2020, because of the lockdown in China, the national lockdowns that have been imposed by national authorities throughout the European Union during the second quarter of 2020 had the effect of increasing the volumes handled at the terminal, due to the increased use of e-commerce and the related demand for home delivery of goods.

Regarding the costs incurred for operating the terminal, it was not possible for the terminal's management to provide reliable estimates of the incidence of different cost items on the cost structure. Nonetheless, it has been explained that most of the costs stem from investment in the equipment and energy to run the equipment, whereas staff represent only a small part of the annual costs; moreover, the high level of automation at the terminal also implies that investments in automated processes are higher than in more traditional terminals, and that staff costs are lower. As the investment costs, which represent the lion share of the annual costs, are fixed, the cost structure of the terminal can be defined as relatively rigid, although the recent increase in the prices of fuels and energy might have increased the share of variable costs.

It should be noted, though, that the costs associated with the different types of freight transport modalities are not the same. Indeed, while the unloading of intermodal units from deep-sea vessels and the consequent loading onto trucks is completely automated and done by automatically driven vehicles, the loading of containers onto barges and short-sea vessels requires the use of slower transshipment technologies, with higher energy expenditure, and the loading of containers on trains is the only process at the terminal that is not automated, thus requiring additional personnel costs. Therefore, operating hours, staff and energy costs are usually higher for train freight transport compared to road haulage, making it also less attractive for customers. Nonetheless, it should be noted that this is due to the higher costs incurred by the terminal for the transshipment between from deep-sea vessels to different modalities, and not an effect of the time; as the container are usually stored for a few days in the terminal, the impact of the time required for transshipment has virtually no effect on the final cost.

Annex 20.3 **Future expected demand and planned investments**

The current capacity of the terminal amounts to approximately 2,350,000 TEU/year, but could easily be expanded to handle higher volumes in the future. The investment will involve the construction of a new berth served by five cranes, as well as an increase in stocking and handling capacity for the barge/feeder quay. At the moment, RWG has no plan to invest in the expansion of its rail terminal, as it considers that there is still enough spare capacity to handle any increase in demand that might stem from the modal shift to rail.

According to RWG's management, a modal shift from road to rail or waterway might take place, given that the train and barges are more sustainable than trucks, but the terminal is not in a position to promote the modal shift, as it only handles the loading and unloading of the containers into the intermodal units chosen by the shipping lines, and thus has no influence on the hinterland transport modality chosen. Nonetheless, the RWG terminal is supporting the modal shift by improving the reliability of the services offered for sustainable transport modalities. For instance, the RWG terminal has dedicated some of its handling capacity specifically to the rail and waterway transport modalities.

RWG's management considers that, if the European Union achieves its goal to double the volume of freight moved via rail by 2050, the terminal is capable of handling an increased volume of freight with the current infrastructure. Indeed, the terminal could handle at least 20% more barges and trains. However, the goal is considered difficult to reach, as the railway sector is not in a position to cope with such an increase. This is mainly because of the lack of and adequate railway network throughout the European Union and the poor organisation of the sector.

For instance, while the Netherlands has rail tracks that are dedicated to freight transport, intermodal operators have to book rail tracks approximately one year in advance to move their freight to other countries such as Germany, because the network is congested and therefore cannot handle an unexpected increase in traffic. This is one of the key factors that makes the railway modality less attractive when compared to road haulage, which is considered to be more reliable and flexible, allowing for changes of schedule when needed.

Moreover, it seems that the modal shift towards rail and inland waterways is also hindered by a lack of organisation along the whole logistic chain, involving not only shipping lines but also RU and inland waterway operators. The terminal's management has explained that it is not unusual for barges and trains to stop at multiple terminals within the port of Rotterdam in order to collect containers from each of them. This process increases the time needed for the barges and trains to fill all the space available, and therefore the associated costs, with the effect of disincentivising logistic companies from choosing rail and barges over trucks; indeed, every truck can collect its container from a single terminal, making it a faster and thus cheaper solution.

Annex 20.4 **Impact and pass-through of state support measures**

The development of the RWG terminal has been partially funded by the Trans-European Transport Network (TEN-T) programme, with the aim of building a sustainable container terminal, dedicated to the rail and barge freight handling, to increase the intermodal transport between the port of Rotterdam and the European hinterland. The goal was to reduce the road modal share from 50% to 35%. The TEN-T covered €5 million to the development of the RWG terminal, between 2012 and 2014.[488]

Nonetheless, RWG's management has stated that it is difficult to assess whether the aid received from the European Commission has translated into lower prices for the shipping companies since further investments were required by the RWG terminal to improve the quality of the handling. Moreover, that was not the goal of the subsidy.

Annex 20.5 **Clean technologies**

The rail tracks located inside RWG are not electrified, because reach stackers are top lifting and therefore an overhead catenary line would interfere with the loading and unloading of containers from the trains.

As RU are not direct clients of the terminal, RWG's management does not know whether the trains that arrive at the terminal use diesel locomotives or electric battery, and is in no position to provide information regarding the investment and operating costs related to clean technologies for rolling stock.

Annex 20.6 **Main findings**

The Rotterdam World Gateway terminal has a relatively rigid cost structure. The terminal relies on a high level of automation to handle most of its cargo, requiring high investments in the infrastructure, which is independent from the level of freight moved. Nonetheless, there is some heterogeneity in the costs associated with the different freight transport modalities. Indeed, while the unloading of intermodal units from deep-sea vessels and the consequent loading onto trucks is completely automated and done by automatically driven vehicles, the loading of containers onto barges and short-sea vessels requires the use of slower transshipment technologies, with higher energy expenditure, and the loading of containers on trains is the only process at the terminal that is not automated, thus requiring additional personnel costs. Therefore, operating hours, staff and energy costs are usually higher for train freight transport compared to road haulage, making it also less attractive for customers.

RWG is a container terminal, and as such it does not offer complementary services such as shunting and marshalling, container maintenance or weighting. The bulk of revenues stems from the handling (i.e., loading and unloading) of the intermodal units from the deep-sea vessels. Indeed, only deep-sea shipping lines are direct customers of the RWG terminal, and the terminal has no contractual relationship with the other freight transport modalities operators (rail, road, barge, feeders), but the handling of the cargo for other modalities, which is reliant on the contract with the shipping lines, contributes to the financial performance of the terminal. According to the terminal's management, the terminal operations are profitable: profit margins on total turnover can be estimated to be around 10%.

Differently from other terminals, the effect of the COVID-19 outbreak has been overall beneficial for the RWG terminal; while it has caused a small reduction in the inbound freight traffic in the first quarter of 2020 because of the lockdown in China, the national lockdowns that took place in Europe during the second quarter of 2020 have led to an important increase in the volume of freight handled at RWG because of an increase in e-commerce, and the related demand for home delivery of goods.

The terminal is operating at full capacity for its deep-sea line of business, whereas it would be able to handle approximately 20% more trains and freight. Thus, the terminal's management considers that there is enough capacity to reach the goal of doubling the rail modal share by 2050. Nonetheless, it was pointed out that the current railway infrastructure is considered to be inadequate to support the modal shift. The issue lies in

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[488] See TENT-T project 2011-NL-91116-P.

the congestion of the network, which seems to be a widespread issue, although this is more remarked in some countries. For instance, RWG reported that in Germany RU need to book the rail tracks around one year in advance to ensure that there is enough capacity in the network, whereas Netherlands has rail tracks dedicated to freight transport, and congestion seems to be less of an issue.

Another bottleneck that could hinder the modal shift arises at the level of the logistic organisation of shipping companies. It is not unusual for inland waterway operators and RU to collect containers from different terminals within the port of Rotterdam. This increases the times and costs of these modalities for the final user, and disincentivise their use compared to road haulage, which is comparatively faster and cheaper.

Finally, while the transshipment from deep-sea vessels to trains, trucks, barges and feeders requires different times, this has virtually no impact on the costs of the intermodal transport, as the container are usually stored for a few days in the terminal, so that the impact of the transshipment time on the final cost is not relevant.

Annex 21 Sources for cost, revenues and profitability of rail freight

Table 85 presents sources used for the purposes of the presentation of costs, revenues and profits.

Table 85: Presentation of costs, revenues and profits (sources)

Year	Sources
2015	Herry Study
2019	Incumbent Rail Cargo annual report
2018	Eurostat rail_go_typepas
2019	9th IRG Fig. 15 working document
2019	Eurostat rail_go_typepas
2020	Eurostat rail_go_typepas
2019	Incumbent CD Cargo annual report
2019	Market Regulator UPDI survey
2019	Market Regulator UPDI survey, Volume-weighted Geo. Revenues
2020	Market Regulator UPDI survey
2020	Market Regulator UPDI survey, Volume-weighted Geo. Revenues
2019	Responces to stakeholders consultation [Confidential]
2018	8th IRG Fig. 15 working document
2019	Market regulator Autorite de regulation des transports annual report
2018	Responces to stakeholders consultation [Confidential]
2020	Responces to stakeholders consultation [Confidential]
2019	Incumbent DB Cargo financial report 2019

2020	Incumbent DB Cargo financial report 2020
2020	UIC DB AG
2019	Market Regulator Bundesnetzagentur market report
2019	Non Incumbent Captrain Deutschland CargoWest annual report
2019	Non Incumbent Mitteldeutsche Eisenbahn annual report
2019	Non Incumbent RTB Cargo annual report
2019	Non Incumbent Rhein Cargo annual report
2019	Industry Association VDV market report
2020	Industry Association VDV market report
2020	Industry Association VDV market report, Own calculations, Variable Cost Items Summed
2019	UIC FS
2019	Incumbent LTG Cargo annual report
2019	Infrastructure Manager LTG Infra survey
2020	Infrastructure Manager LTG Infra survey
2019	Infrastructure Manager LTG Infra survey, Volume-weighted Geo. Revenues
2019	Infrastructure Manager LTG Infra survey, Volume-weighted Traintype Revenues and Costs
2020	Infrastructure Manager LTG Infra survey, Volume-weighted Geo. Revenues
2020	Infrastructure Manager LTG Infra survey, Volume-weighted Traintype Revenues and Costs
2018	Panteia
2018	Panteia, Own calculations, Mean Calculated Across Freight Categories and Trian Types
2019	Market Regulator ACM short profitability survey
2019	Incumbent PKP Cargo annual report
2018	Incumbent PKP Cargo survey
2019	Incumbent PKP Cargo survey
2020	Incumbent PKP Cargo survey
2018	Non Incumbent Lotos Survey
2019	Non Incumbent Lotos Survey
2020	Non Incumbent Lotos Survey
2019	Market Regulator UTK survey

2020	Market Regulator UTK survey
2019	Market Regulator UTK
2019	Regulator´s report PDF
2020	Market Regulator UTK
2018	Incumbent CRF Marfa annual report
2018	UIC CFR Marfa
2018	UIC CTV Cargo Trans Vagon
2018	UIC GFR Grup Ferroviar Roman
2019	UIC GFR Grup Ferroviar Roman
2018	Statistical Office´s Report
2018	Study on rail freight market P. 29/30
2019	Study on rail freight market P. 29/30
2018	Incumbent ZSSK Cargo annual report
2018	UIC ZSSK Cargo
2019	Incumbent ZSSK Cargo annual report
2019	UIC ZSSK Cargo
2019	Incumbent Renfe Mercancias annual report
2019	Market Regulator CNMC annual report
2019	Market Regulator CNMC annual reprot
2019	Non Incumbent FGC annual report
2019	UIC Euskotren
2019	Market Regulator CNMC survey
2020	Market Regulator CNMC survey
2019	Market Regulator CNMC annual reportVolume-weighted Marketparticipant Revenues and Costs
2020	Incumbent Green Cargo financial report 2020
2019	Market Regulator Swedish Transport Agency survey
2020	Market Regulator Swedish Transport Agency survey
2019	Incumbent SBB annual report
2019	Non Incumbent Swiss Rail Traffic short profitability survey

Source: The Consortium based on data collected from publicly available sources and stakeholder consultation.

Table 86 presents the sources used for the simulation of costs with respect to changes in distance and length.

Table 86: Simulation of cost with respect to distance and length

Year	Sources
2019	Incumbent CD Cargo annual report
2020	Industry Association VDV market report, Own calculations, Variable Cost Items Summed
2019	Incumbent DB Cargo financial report 2019
2020	Incumbent DB Cargo financial report 2020
2019	Non Incumbent Captrain Deutschland CargoWest annual report
2019	Non Incumbent RTB Cargo annual report
2019	Non Incumbent Mitteldeutsche Eisenbahn annual report
2019	Market Regulator Bundesnetzagentur market report
2019	Incumbent LTG Cargo annual report
2018	Panteia
2019	Non Incumbent Lotos Survey
2019	Incumbent PKP Cargo annual report
2020	Market Regulator UTK
2019	Market Regulator UTK
2018	Incumbent CRF Marfa annual report
2019	UIC ZSSK Cargo
2018	UIC ZSSK Cargo
2019	Incumbent Renfe Mercancias annual report
2019	Market Regulator CNMC annual report

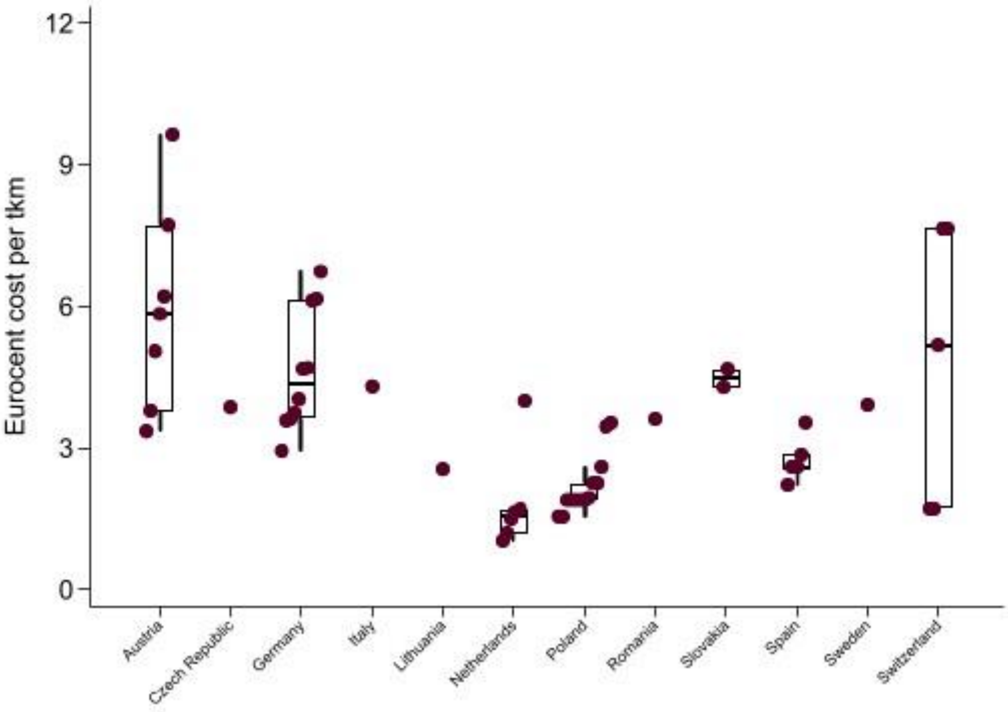
Source: The Consortium based on data collected from publicly available sources and stakeholder consultation. Note that none of these are confidential.

Annex 22 Cost, revenue and profitability ranges

The figures presented in this Section show the reported costs, revenues and profits and the respective ranges to the extent that data is available.

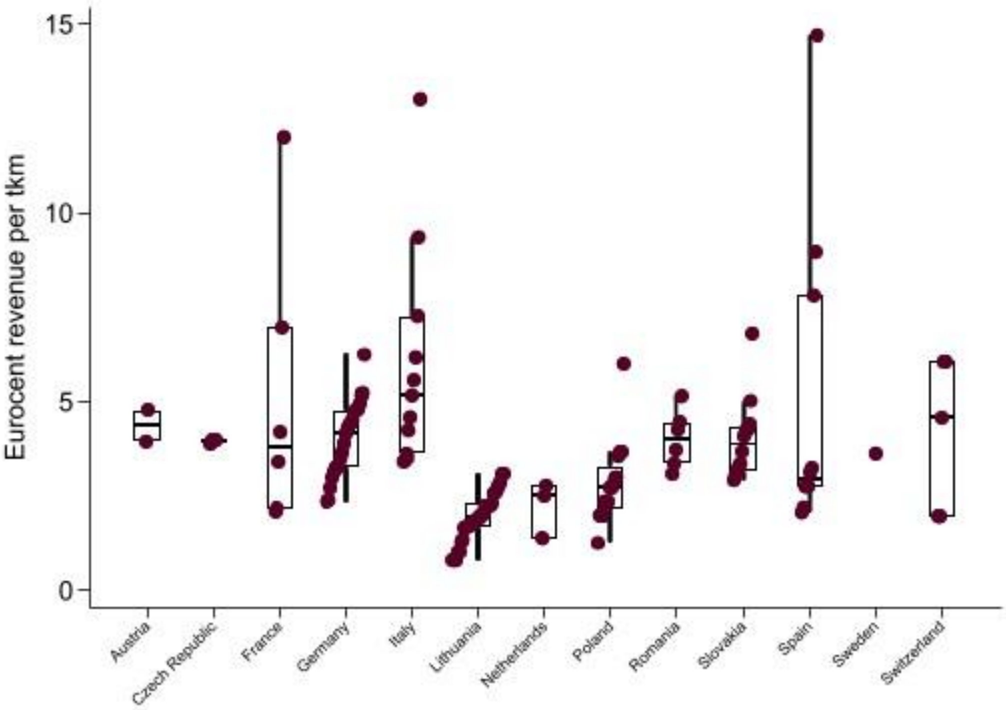
Annex 22.1 Countries

Figure 60: Costs per tkm by country



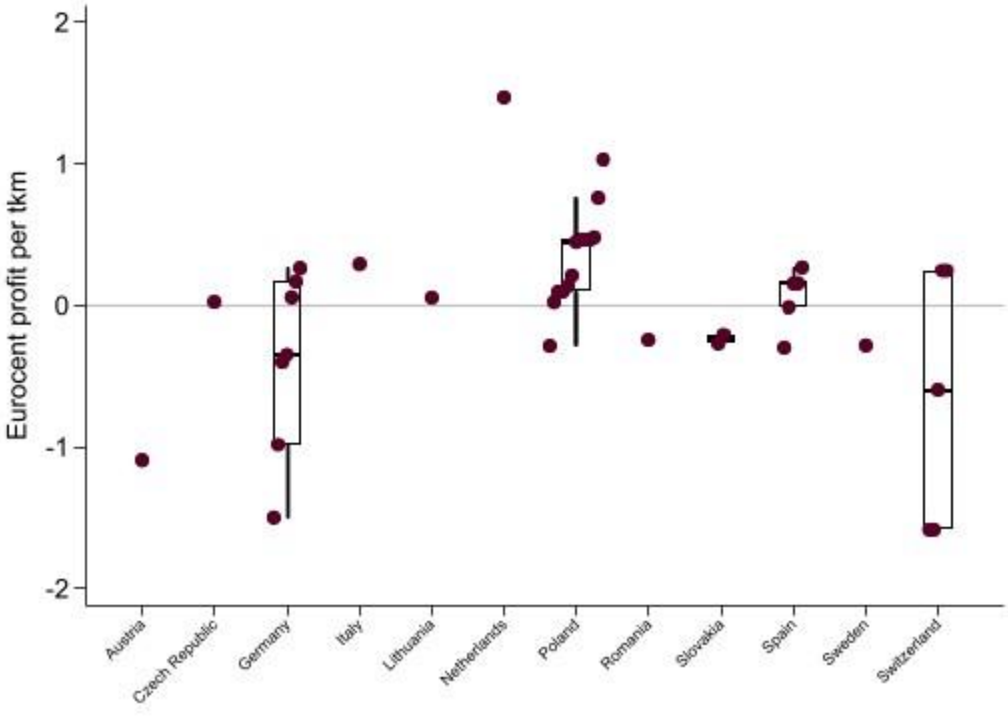
Source: The Consortium based on data collected from publicly available sources and stakeholder consultation.

Figure 61: Revenues per tkm by country



Source: The Consortium based on data collected from publicly available sources and stakeholder consultation.

Figure 62: Profits per tkm by country



Source: The Consortium based on data collected from publicly available sources and stakeholder consultation.

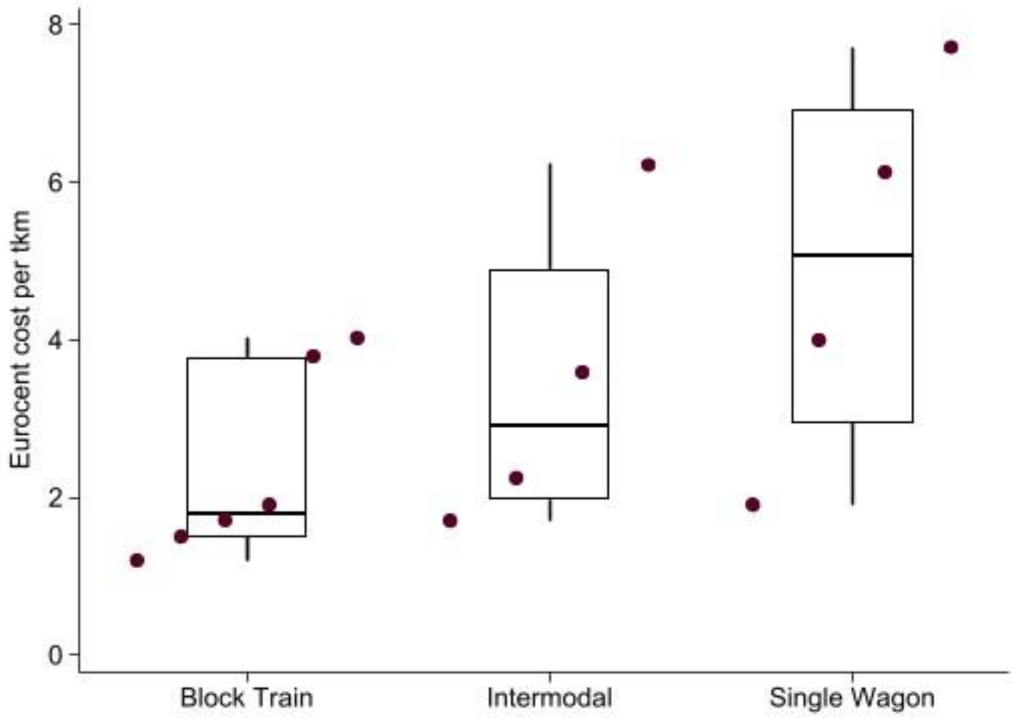
For some countries, we observe a difference in the reported profits and the average profits (see Section 4.2.2):

- For Austria, the reported profit is derived from the overall sector's cost and revenue. The average costs are higher than reported costs since it considers costs pertaining to higher-cost train types (SW and IM) and higher-cost routes (national) compared to the overall sector cost. We lack corresponding revenue data. The lower average profit is therefore driven by higher average costs;
- For Italy, the reported profit is derived from the stakeholder consultation. The average revenues are higher than reported revenues since it considers higher revenue-yielding freight categories (automotive equipment and chemicals), train types (SW) and international routes. We lack corresponding cost data. The higher average profit is therefore driven by higher average revenues.
- For Lithuania, the reported profit is derived from the overall costs and revenues obtained via the stakeholder consultation. The average revenues are lower than reported revenues since it considers lower-revenue yielding freight categories, train types (BT and IM) and geographic scope (international) in Lithuania. We lack corresponding cost data. The lower average profit is therefore driven by lower average revenues;
- For Slovakia, the reported profit is derived from the overall costs and revenues from the stakeholder consultation. The average revenues are lower than reported revenues since it considers lower-revenue yielding freight categories, train types (BT and IM) and geographic scope (international) in Slovakia. We lack corresponding cost data. The lower average profit is therefore driven by lower average revenues.

- For Romania, the reported profit is derived from the overall costs and revenues. The average revenues are higher than reported revenues since it considers higher revenues from international transport as well as revenues from non-incumbents (Incumbent CRF Marfa annual report, 2018; UIC GFR Group Ferroviar Roman, 2018-2019). We lack corresponding cost data. The higher average profit is therefore driven by higher average revenues;
- For Spain, the reported revenues comprise of overall costs and revenues (profitable) and the overall costs and revenues (loss-making) from the stakeholder consultation. Average reveneus however are higher than both reported revenues as it considers higher revenue-yielding freight categories (automotive equipment and metal ores) as well as higher non-incumbent revenues. We lack corresponding cost data. The higher average profit is therefore driven by higher average revenues.

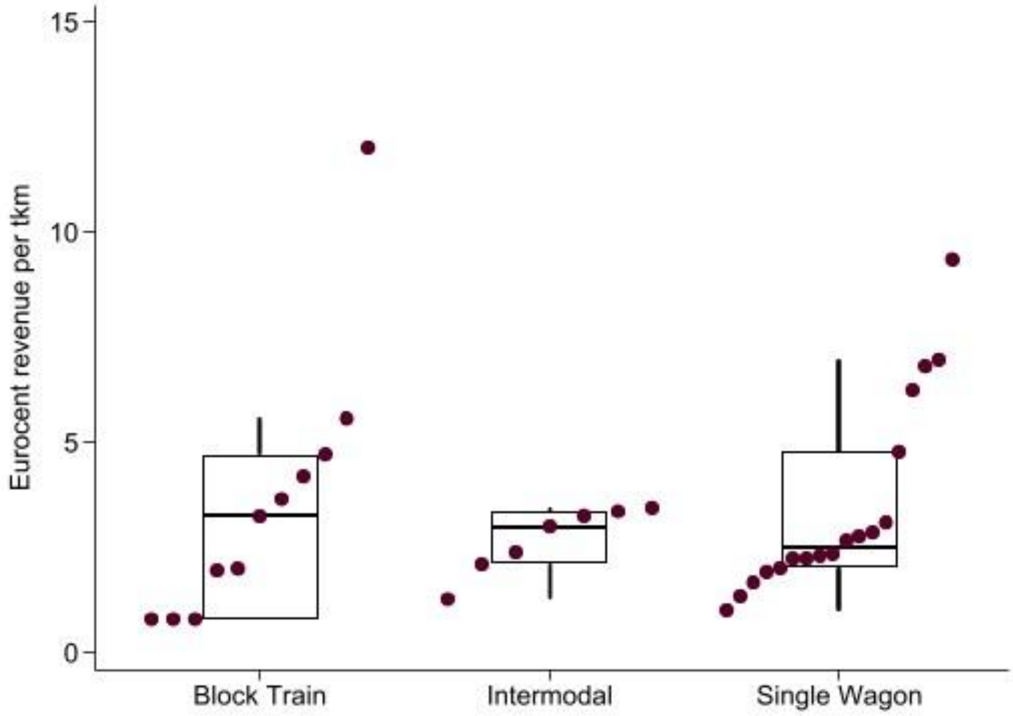
Annex 22.2 **Train types**

Figure 63: Costs per tkm by train type



Source: The Consortium based on data collected from publicly available sources and stakeholder consultation.

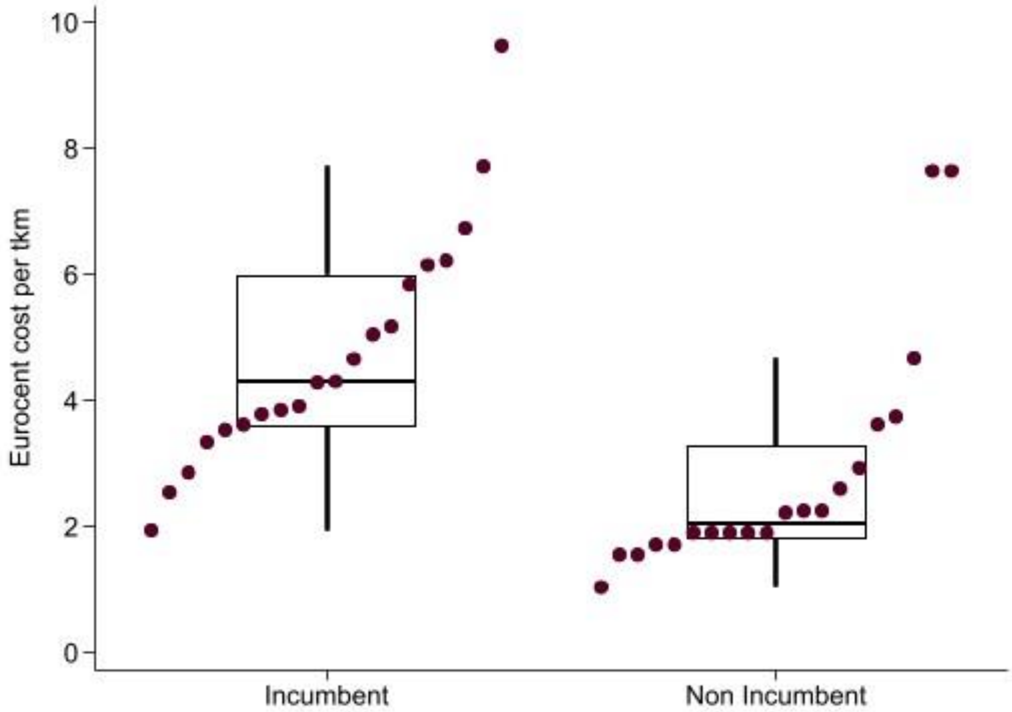
Figure 64: Revenues per tkm by train type



Source: The Consortium based on data collected from publicly available sources and stakeholder consultation.

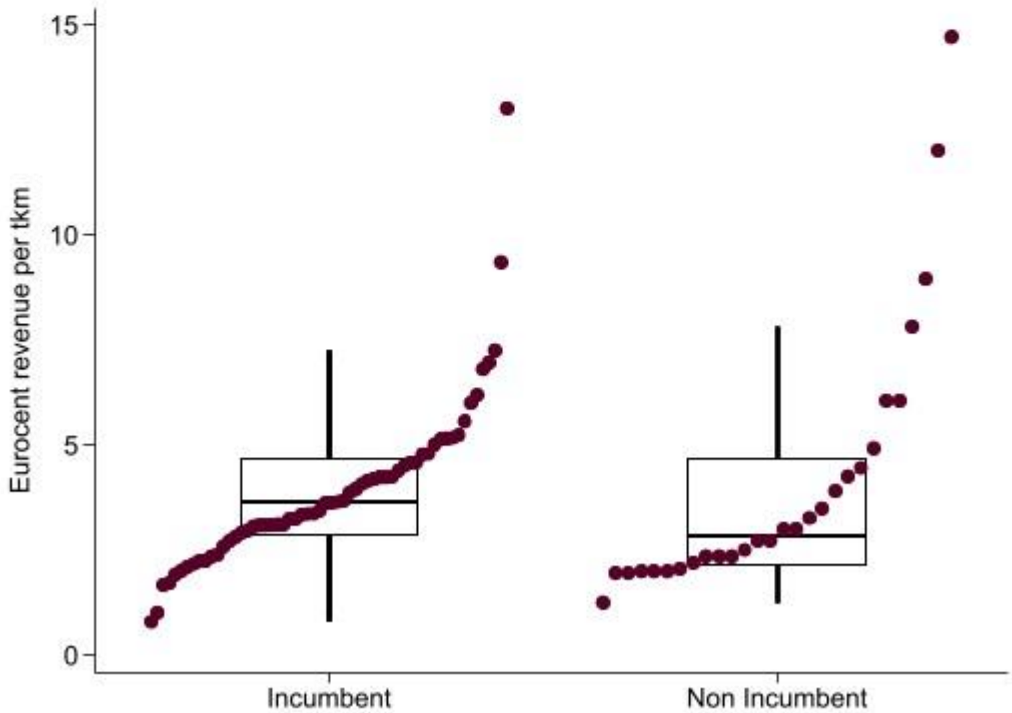
Annex 22.3 **Market participants**

Figure 65: Costs per tkm by market participant



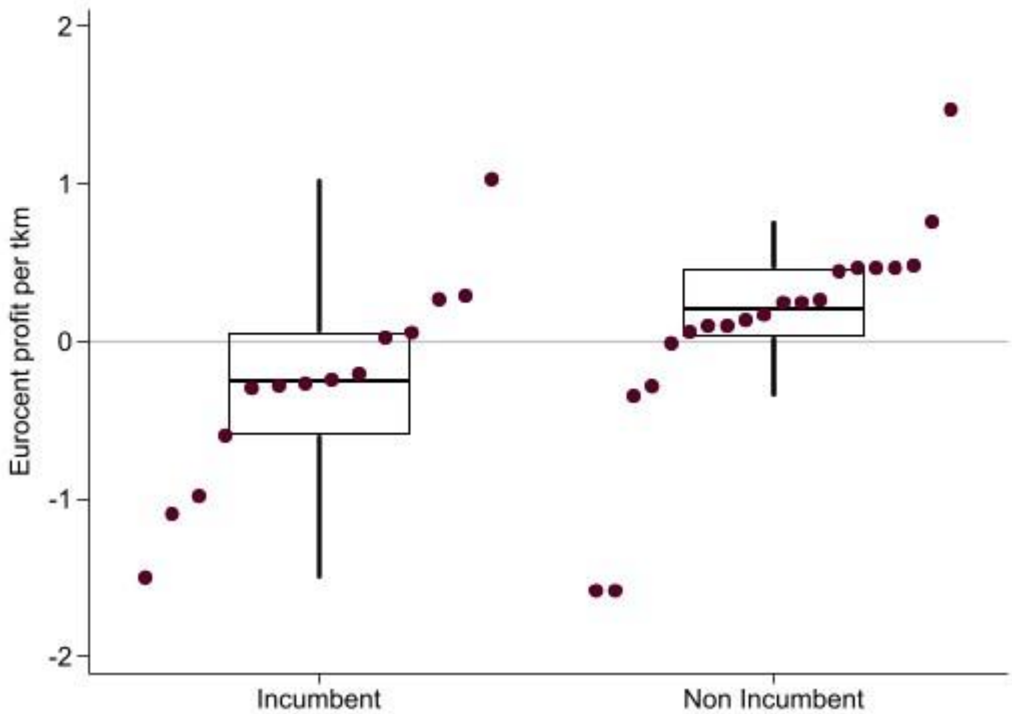
Source: The Consortium based on data collected from publicly available sources and stakeholder consultation.

Figure 66: Revenues per tkm by market participant



Source: The Consortium based on data collected from publicly available sources and stakeholder consultation.

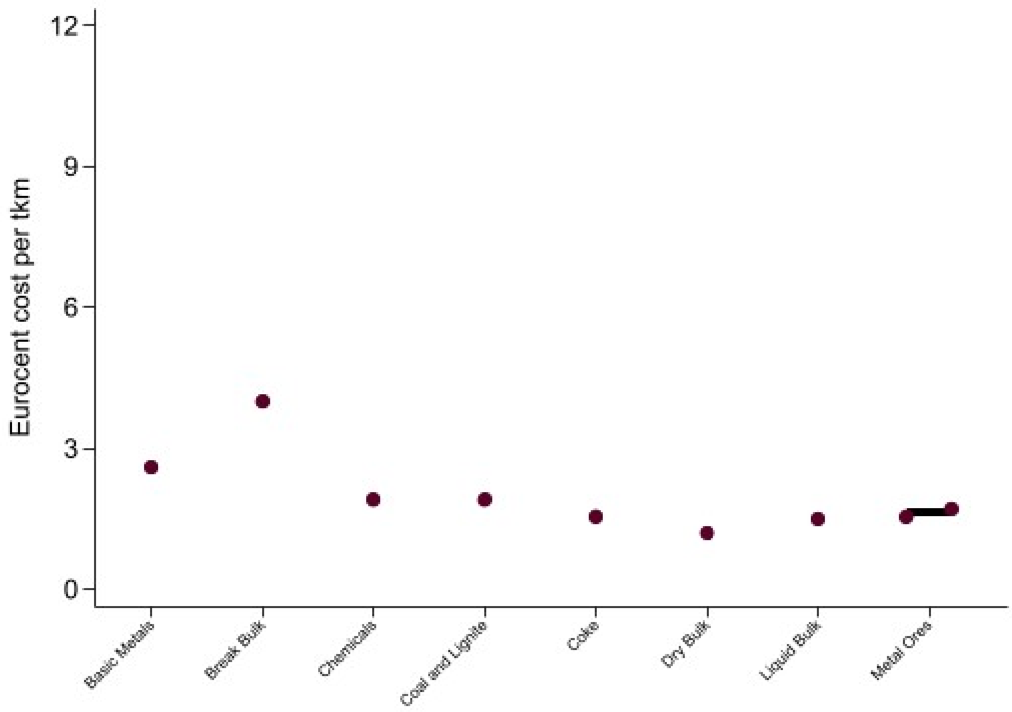
Figure 67: Profits per tkm by market participant



Source: The Consortium based on data collected from publicly available sources and stakeholder consultation.

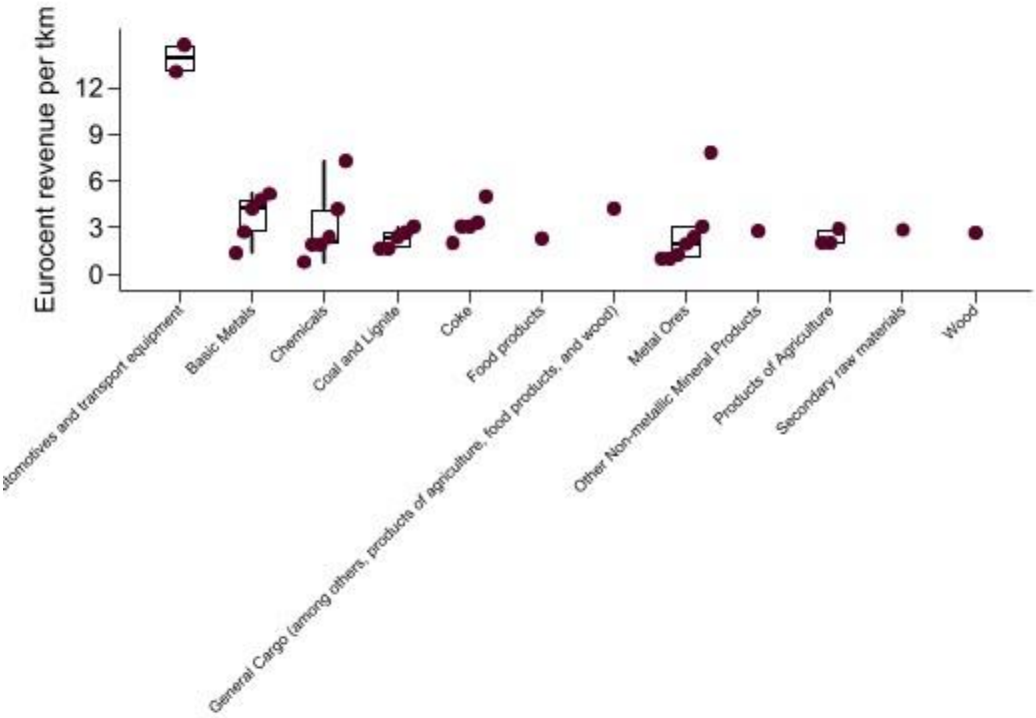
Annex 22.4 **Freight categories**

Figure 68: Costs per tkm by freight category



Source: The Consortium based on data collected from publicly available sources and stakeholder consultation.

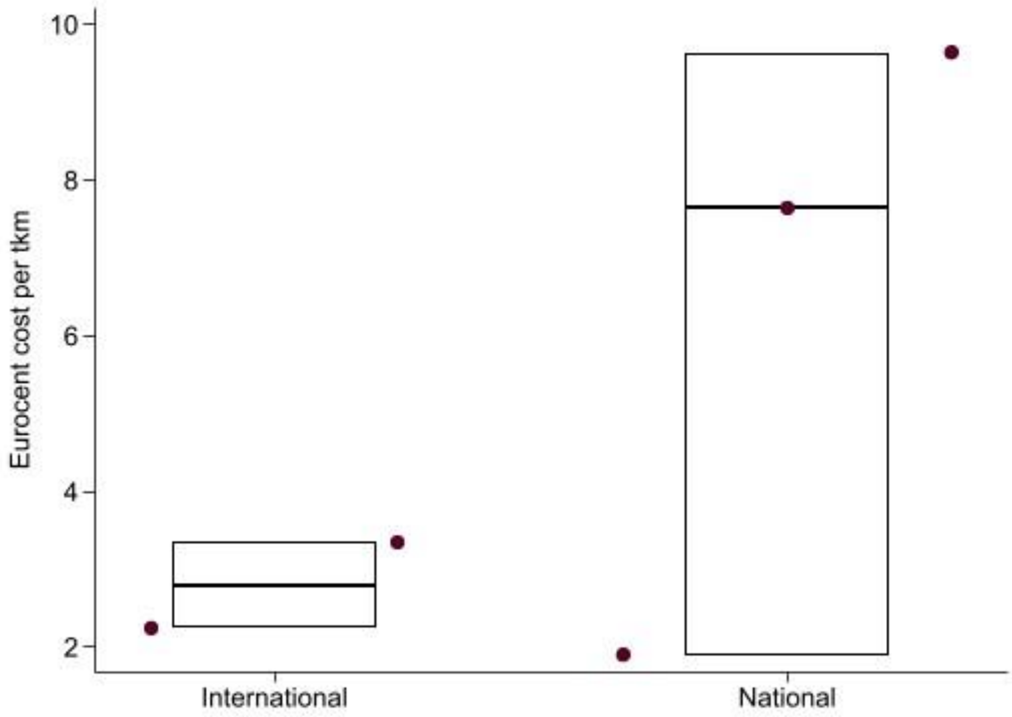
Figure 69: Revenues per tkm by freight category



Source: The Consortium based on data collected from publicly available sources and stakeholder consultation.

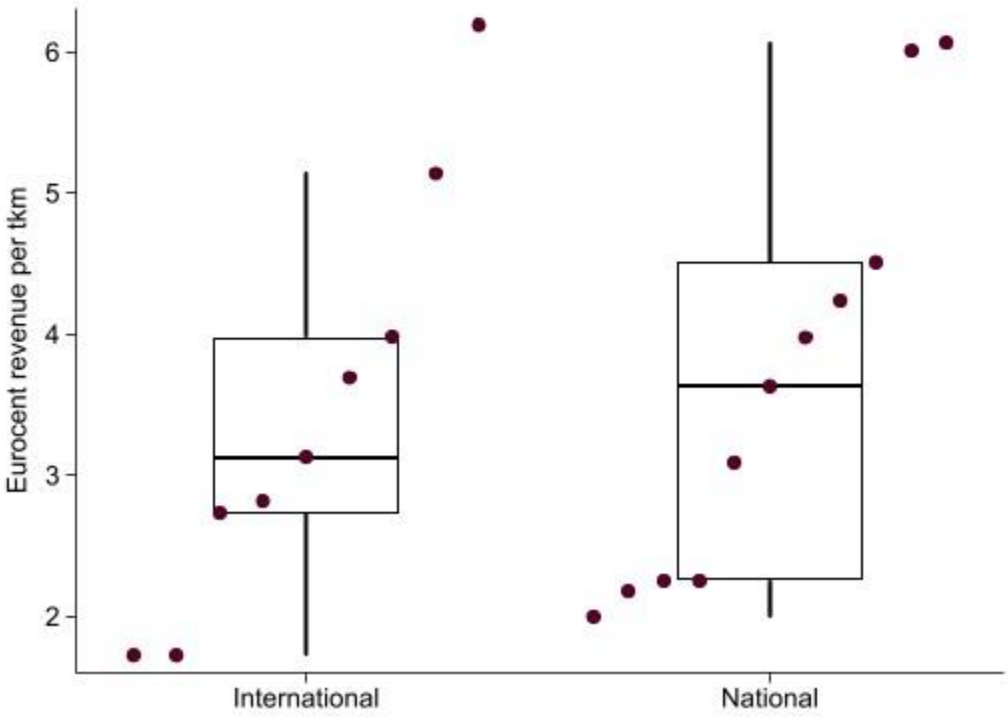
Annex 22.5 **National/international scope**

Figure 70: Costs per tkm by national/international scope



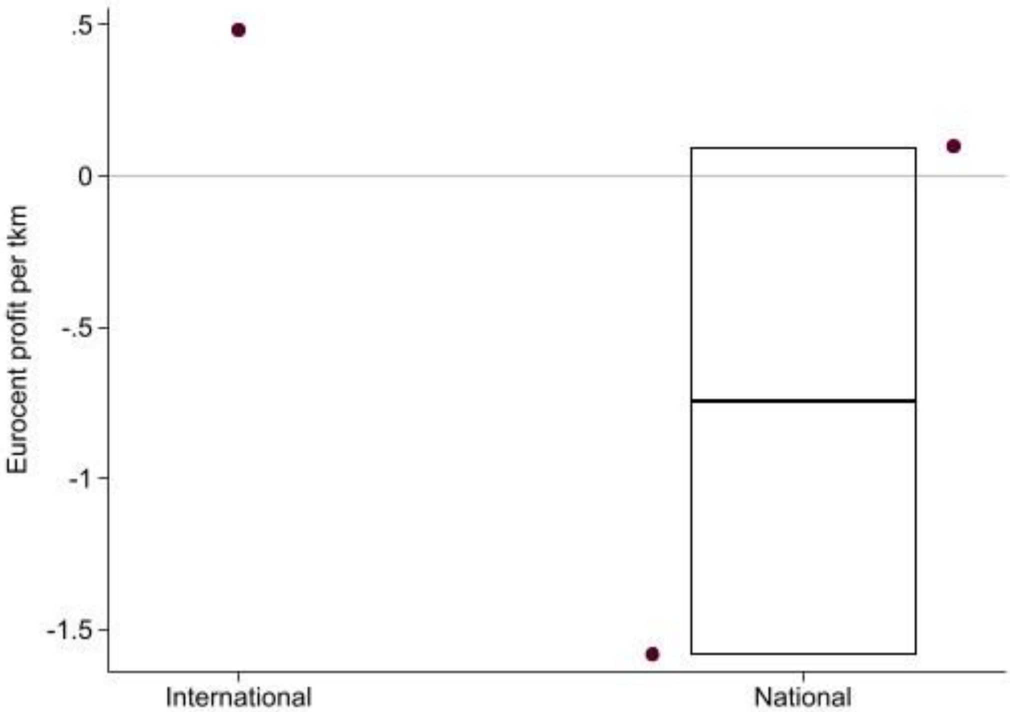
Source: The Consortium based on data collected from publicly available sources and stakeholder consultation.

Figure 71: Revenues per tkm by national/international scope



Source: The Consortium based on data collected from publicly available sources and stakeholder consultation.

Figure 72: Profits per tkm by national/international scope



Source: The Consortium based on data collected from publicly available sources and stakeholder consultation.

Annex 23 Simulation of costs for changes in train length and distance

Annex 23.1 Methodological details

We model the estimates using the following given data:

- Average distance travelled and average length.
- A split of average costs per tkm into cost items (in %) as provided in the incumbent's annual reports, market regulator's report and/or industry reports and via input from stakeholder consultation.
- Average costs per tkm as provided in the incumbent's annual reports, market regulator's report and/or industry reports and via input from stakeholder consultation.

For a given increase in distance or train length, we scale up the variable share of costs (for the entire trip) proportionately and find that when this is divided by the new distance, the average costs per tkm decrease.

For distance travelled, we:

- First, find the cost items such as track access charges, energy and labour costs applicable to the average distance travelled using both the average costs per tkm (EUR per tkm) as well as the share of those cost items in %.
- We then consider the relationship between the average costs per tkm and the overall distance travelled and find that that it takes the following functional form:

$$Function\ (\Delta\ distance) = \frac{(Avg.transport\ distance\ + \Delta\ distance * share\ of\ var.costs\ in\ avg.costs}{\Delta\ distance} * avg.cost\ per\ tkm$$

For train length, we:

- Find the cost items such as traction, rolling stock and terminal services. As regards rolling stock, to the extent possible, we adjust this to the costs that are attributable to wagons (rather than total rolling stock costs that includes locomotive costs).
- Note that we adjust the rolling stock cost shares for each country while accounting for differences in the average train length, to consider only the wagon-specific rolling stock shares. While there is limited publicly available data distinguishing between overall rolling stock costs and wagon-specific rolling stock costs, we found two sources (JASPERS 2017 and Renfe's Annual Report 2019), that suggested on average, wagons make up around 30% of the total rolling stock costs for Spain.[489] Using this estimate as a baseline, we approximate the wagon-specific rolling stock shares for other countries and dimensions by adjusting the total rolling stock costs and subsequently the wagon-specific rolling stock costs for the number of wagons specific to each country and dimension. We also adjust labour costs to consider only the "variable" proportion of labour costs (for example, costs related to train crew).[490]
- Similar to the above function, we model the change in train length as a function of the average number of wagons and the share of costs that is variable with train length (i.e. train-length dependent) as a proportion of overall costs.

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[489] Note that this is computed by considering an average of wagon-specific rolling stock costs as a proportion of the total rolling stock costs, and applying this to the average train length of a train in Spain.
[490] For countries that do not have this estimate, we use the average proportion of labour costs that are variable.

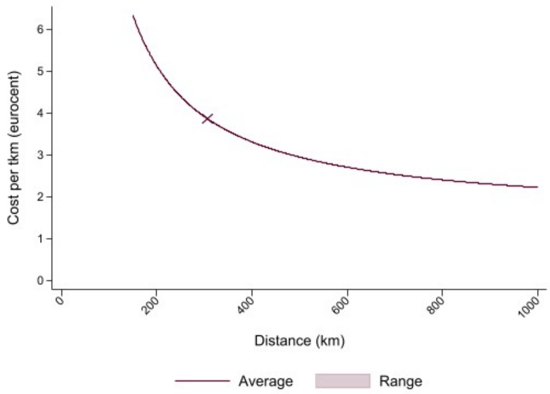
Annex 23.2 Average variable cost shares by country

We make the following observations regarding the different variable cost shares across the different countries to the extent that we have this data (Table 17, Section 4.3):

- The proportion of costs attributable to traction are among the highest in Poland, Romania, the Netherlands and Spain.
- The proportion of wagon-specific rolling stock costs appear to be high in Netherlands, France and Slovakia. The share depends on factors such as the age and utilisation of rolling stock and the type of infrastructure present in the respective countries. For instance, Lithuania and Poland seem to be generally more efficient with overall lower costs, which may be attributable to the low shares of wagon-specific rolling stock costs.
- Romania has the highest share attributable to labour costs. This may be influenced by the strong presence of unionised labour in the country, where historically there is some evidence of pressure on RU to increase wages.[491]
- Moreover, the Netherlands has a very low share of variable labour costs. This data is sourced from Panteia (2020) and may be influenced by certain modelling assumptions and differences in reporting methodologies.
- Lithuania has a very high share of track access charges. This share was validated by the information we gathered from the stakeholder interviews.

Annex 23.3 Country-level costs per tkm by distance and length

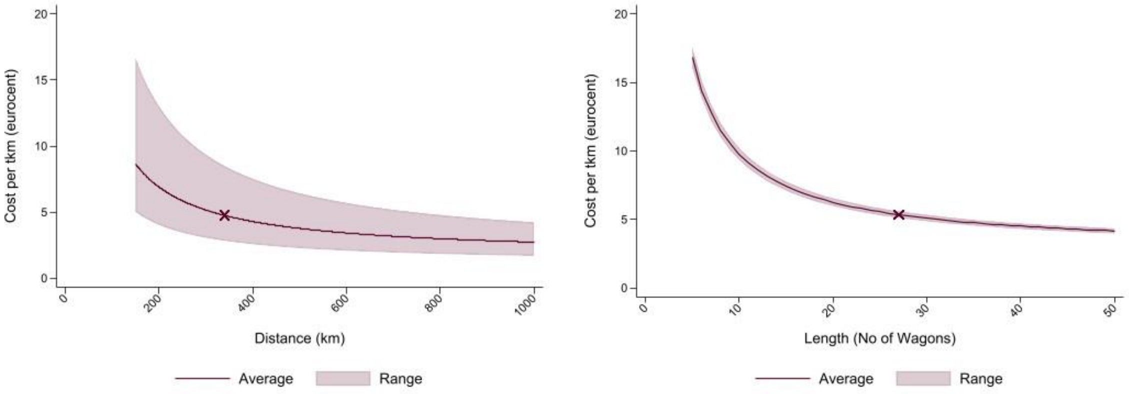
Figure 73: Costs per tkm by distance: Czech Republic



Source: The Consortium based on data collected from publicly available sources and stakeholder consultation. Note that we have no data to assess changes in costs due to changes in train length.

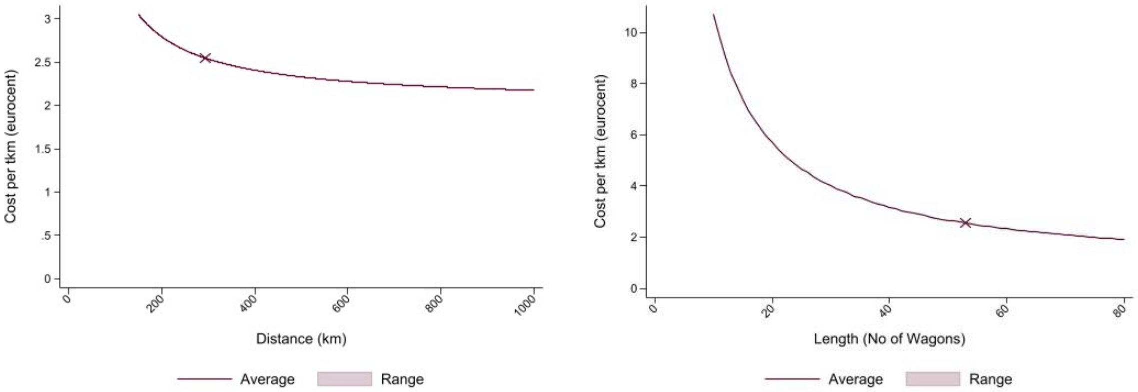
[491] See "Romanian railway workers ask for higher wages": https://www.romania-insider.com/cfr-workers-ask-higher-wages.

Figure 74: Costs per tkm by distance and length: Germany



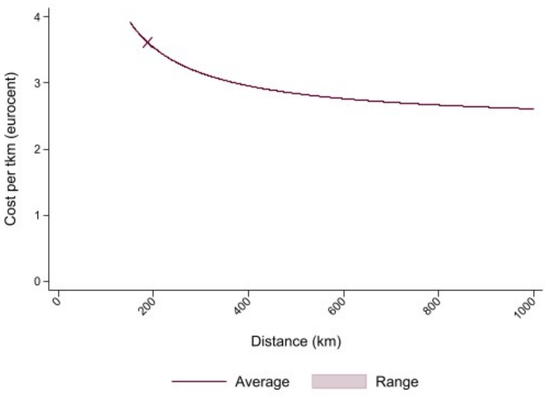
Source: The Consortium based on data collected from publicly available sources and stakeholder consultation.

Figure 75: Costs per tkm by distance and length: Lithuania



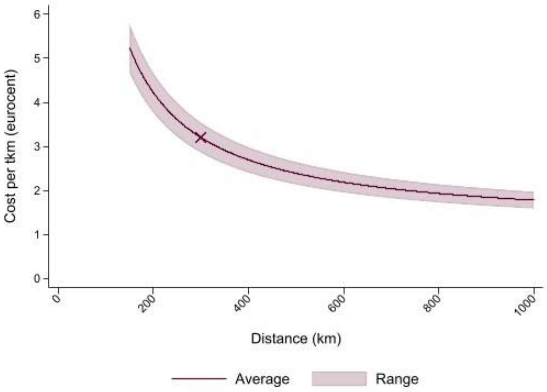
Source: The Consortium based on publicly available sources and stakeholder consultation. Note that we only have one observation for the variable cost share and length pertaining to Lithuania.

Figure 76: Costs per tkm by distance and length: Romania



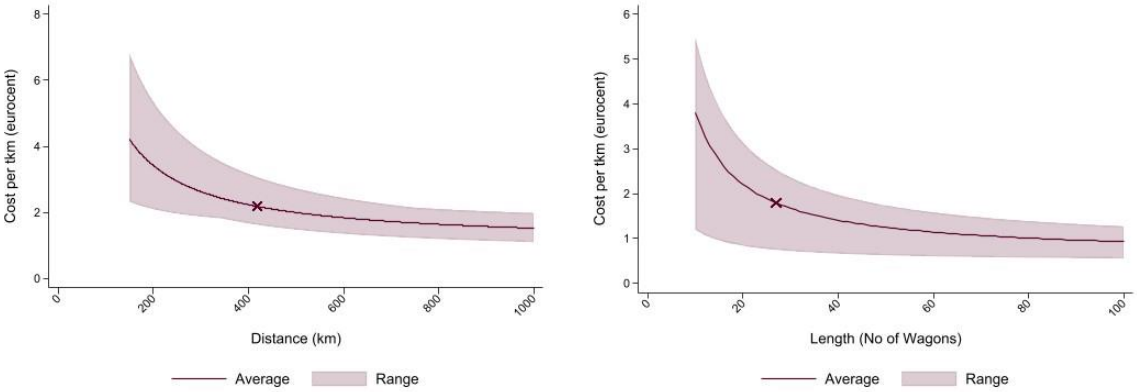
Source: The Consortium based on publicly available sources and stakeholder consultation. Note that we don't have data to assess changes in length for Romania.

Figure 77: Costs per tkm by distance and length: Spain



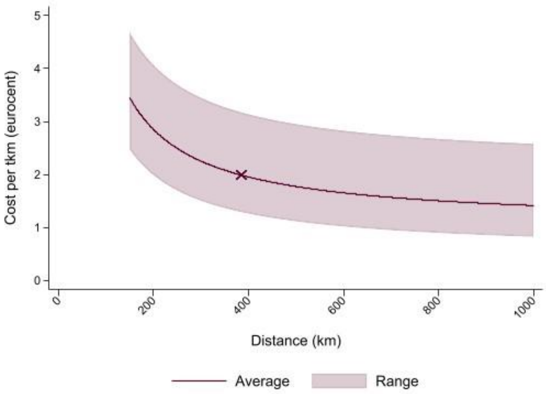
Source: The Consortium based on publicly available sources and stakeholder consultation. Note that we don't have data to assess changes in length for Spain (due to the lack of "terminal services" charges breakdown).

Figure 78: Costs per tkm by distance and length: Poland



Source: The Consortium based on publicly available sources and stakeholder consultation.

Figure 79: Costs per tkm by distance and length: Netherlands



Source: The Consortium based on publicly available sources and stakeholder consultation. Note that we don't have data to assess changes in length for Netherlands (due to the lack of "terminal services" charges breakdown).

We make the following observations regarding the differences in average distance, length and the respective variable cost shares:

- Countries like Poland and Lithuania have distance-dependent variable cost shares of over 70%. An increase in distance of 100 km subsequently leads to a decrease in average costs per tkm of around 5% - 8%, as compared with countries like Germany and Spain where the variable cost shares make up just around 37% - 39% of total costs, leading to a decrease of between approximately 12%-16% in average costs per tkm for the same increase of 100 km in distance travelled.
- Similarly, countries like the Netherlands and Poland that have average travel distances of between 400 km – 600 km will lead to a decrease in cost of up to 7% - 10%, while countries like Romania having considerably shorter average distances of approximately 187 km can lead to a decrease in cost of up to 12%.
- Overall, the higher the number of wagons, the lower is the decrease in average costs per tkm with changes in length. For example, Lithuania on average has more than 50 wagons for which the decrease in cost is around 1%, compared to a non-incumbent (Lotos) in Poland operating single-wagon transport which has just 5 wagons, the decrease in costs could be up to 12% with an additional wagon.

Annex 24 Cross-border effects: detailed data

Table 87: Cross-border effects and related cost increases

Border	Spain - France (axle change)	Spain - France (transshipment)	Spain - France (LFP UIC line)	Spain - Portugal	Lithuania-Poland
Country	*Spain*	*Spain*	*Spain*	*Spain*	*Lithuania*
Market Participant	*Total*	*Total*	*Total*	*Total*	*Incumbent/Total*
Average Cost (Eurocent/tkm)	2.60	2.60	2.60	2.60	2.55
Average Distance (Km)	407.72	407.72	407.72	407.72	293.09
Average Speed (Km/h)	24.70	24.70	24.70	24.70	24.70
Average Time (h)	16.51	16.51	16.51	16.51	11.87
Wait Time (h)	10.00	10.00	0.08	0.17	5.00
Rolling Stock Costs (Increase)	*Included in Transshipment Costs*			15%	27.14%
Labour Costs (Increase)	15.00%	15.00%	12.50%	12.5%	15.00%
Baseline Rolling Stock Costs (Eurocent/tkm)	0.45	0.45	0.45	0.45	0.31
Baseline Labour Costs (Eurocent/tkm)	0.45	0.45	0.45	0.45	0.21
Total Affected Baseline Costs (Eurocent/tkm)	0.90	0.90	0.90	0.90	0.53
Adjusted Rolling Stock Costs (Eurocent/tkm)	0.45	0.45	0.45	0.52	0.40
Adjusted Labour Costs (Eurocent/tkm)	0.52	0.52	0.51	0.51	0.24

Wait-time related labour costs (Eurocent/tkm)	0.27	0.27	0.00	0.00	0.09
Transshipment (Eurocent/tkm)	1.56	0.66	0.33	-	0.31
Total Affected New Costs (Eurocent/tkm)	2.80	1.90	1.29	1.03	1.04
Change in Costs (as a share of total costs) %	73.22%	38.64%	15.03%	4.93%	20.20%
New Average Cost due to Cross-border effects (Eurocent per tkm)	4.50	3.60	2.99	2.73	3.07

Source: The Consortium based on publicly available sources and stakeholder consultation.

Annex 25 Transshipment costs

We received transshipment cost information in terms of per train or per wagon. We therefore use the following data (and sources) to convert these estimates into costs in terms of eurocent per tkm, to ensure consistency with the remainder of our cost-revenue framework.

Table 88 provides train weights for the cargo being transported, by train type, for a single-wagon. For the simulation of cross-border effects, we consider an average across the three train types.

Table 88: Average tonnage of freight

Train Types	Tonnage
Block Train and Single-wagon	63.5
Container	25
Overall Average	44.25

Source: The Consortium based on JASPERS, Table A.10.

Table 89 provides transshipment cost estimates and the necessary conversions to arrive at a cost of eurocent per tkm, in case of break-of gauge.

Table 89: Lithuania transshipment costs

Category	Costs
Transshipment Cost per Wagon	30 - 50 EUR per wagon
Average Cost	40
Cost Per wagon per tonne (Euro)	0.903
Average Distance (Km)	293.09
Cost Per wagon per km (avg distance) (Euro per km)	0.003
Cost Per wagon per km (avg distance) (Eurocent per km)	0.308

Source: The Consortium based on JASPERS, Interview with LTG Cargo, Eurostat.

Table 90 provides transshipment costs for the Spain-France border, and the associated conversions to arrive at a cost of eurocent per tkm in case of each solution to break-of-gauge.

Table 90: Spain-France transshipment costs

Spain-France	Axle Change	Transshipment	LFP UIC
Cost per train	4,000 EUR per train	1,700 EUR per train	850 EUR per train
Average no of wagons	14.2	14.2	14.2
Cost per wagon (Euro)	282.09	119.89	59.94
Cost Per wagon per tonne (Euro)	6.37	2.71	1.35
Average Distance (Km)	407.72	407.72	407.72

Per wagon per tonne per km (Euro per tkm)	0.02	0.01	0.00
Per wagon per tonne per km (Eurocent per tkm)	1.56	0.66	0.33

Source: The Consortium based on AEFP, Spanish Infrastructure Manager data (2019), JASPERS, Eurostat.

Annex 26 Complementary and short-distance rail services

Transporting goods via rail is a complex task and goes beyond the core transport of goods with a mainline locomotive and rail freight wagons. In particular, a rail freight service requires local and regional services as inputs (i.e. complementary services), without which the main service cannot be offered. Section 2.3 discusses essential facilities like marshalling yards whose services RU require for their operations. In addition to inputs from essential facilities, RU offering long-distance rail freight services often require rail services as inputs, such as shunting or marshalling or regional distribution services for single-wagons. Such services are in some cases provided by small RU which specialise in short-distance rail freight services within a region. While there is no clear-cut definition of short- and long-distance rail freight operation, this annex sheds some light on the supply of short-distance rail freight services.

We will discuss two main types of short-distance rail freight services. Firstly, local shunting and marshalling activities, which is limited to assembly and disassembly of full trains (from and to individual wagons) by shunting locomotives. Secondly, short-distance freight transport, which includes regional feeder and distribution traffic. The latter is particularly relevant for single-wagon operations. Individual wagons or groups of wagons need to be picked up at rail sidings and brought to a train formation yard in turn forming a part of the local or regional distribution services. Moreover, short-distance freight transport may also include short-distance services for regional clients, e.g. serving local industrial sites. Both types of short-distance operations are provided by licensed railway undertakings.

Section 2.3 highlights that RU can provide complementary services internally or procure them externally. This also applies to short-distance rail services. Consider a railway undertaking offering a single-wagon service. This undertaking may own and manage shunting locomotives, and collect the individual wagons from sidings and assemble the train on a marshalling yard using own equipment and staff. Alternatively, it could source these services externally, such as from other RU, infrastructure managers or other third parties. Such sourcing is only possible, however, if these services are available in the given region and can be accessed at a reasonable price.

Besides the presented market structure in Table 20 of Section 4.4.3, we use two additional sources to assess the supply structure of short-distance operators in MS. Firstly, we utilise insights from the stakeholder consultation. Secondly, we summarise information gathered from public sources and interviews.

Insights from stakeholder consultation

We assess availability and access to short-distance operations based on responses of market regulators during the stakeholder consultation. Table 91 and Table 92 provide country-level information on short-distance services.

Table 91: Types of market participants offering short-distance services

Type of short-distance services	Incumbent	Market share of the incumbent	Other rail freight operators	Other providers
Distribution Services	Yes (DE,IT,anon) No (-)	IT:41-50%	Yes (DE,IT,anon,PL) No (-)	Yes (DE,anon) No (IT)

		anon:91-100%		
Marshalling/ Shunting	Yes (DE,ES,IT,anon,PL,SE) No (-)	IT:41-50% SE:51-60% DE:61-70% ES:91-100% anon:91-100%	Yes (DE,IT,anon,PL,SE) No (ES)	Yes (DE,anon,PL,SE) No (ES, IT)

Source: Stakeholder consultation. Answers of one respondent are anonymised for confidentiality reasons.
Note: Empty brackets "(-)" indicate that no market regulator chose that option.

Table 91 suggests that incumbents are commonly active providers of marshalling and shunting services, although other operators exist. The responses to feeder and distribution services were lower in number, but third-part operators seem to play a bigger role and fill to some extent the gap left by incumbents in some MS (Note that the respondents might refer to both distribution by rail and truck or consider only long-distance RU as "proper" RU).

Moreover, incumbents play a major role in short-distance operations. Their market shares in feeder and distribution as well as marshalling and shunting services range from about 45% to virtually 100% in the countries covered by this analysis.

Table 92: Stakeholders' assessment of availability and access to short-distance services

Type of short-distance services	Availability of services	Access to existing services	Price and access regulated	Price level
Distribution Services	Good (AU,anon)	Good (AU,anon)	Yes (DE) No (AU,anon)	
Marshalling/ Shunting	Good (AU,anon,PL) Medium (ES,SE)	Good (AU,anon,PL) Medium (DE,ES,SE)	Yes (AU,DE,ES,anon,PL,SE) No ()	Somewhat Overpriced (DE,anon) Reasonable (ES,PL,SE)

Source: Stakeholder consultation. Answers of one respondent are anonymised for confidentiality reasons.
Note: Empty brackets "(-)" indicate that no market regulator chose that option.

Market regulators that responded to the stakeholder consultation deem availability and access to marshalling and shunting as medium to good. Two out of two regulators evaluated availability and access to be good.

In line with observed differences in the overall market structure in MS (refer back to Table 3), there are salient differences in the provision of short-distance rail services across MS. For instance, medium access and availability of marshalling and shunting services in Spain coincide with a high market share of the incumbent (90-100%) and no other service providers.

Interestingly, all responsive regulators indicated that price and access to shunting and marshalling operations are regulated, whereas distribution services are mostly not.

Insights from public sources and interviews

Section 4.4.3 concluded that the availability of short-distance services and the market structure of regionally active RU differs substantially between MS. We will now treat two exemplary countries in more detail: Germany and France.

Historically, Germany was the most liberalised country in Europe for rail freight (Slack and Vogt, 2007). Since the German market became deregulated in 1991, 299 companies have obtained licences to haul freight with the result that today the country accommodates the largest number of RU in Europe (SCI, 2005).[492] The multitude of rail freight companies has contributed to a relatively low concentration of the supplier structure. In 2019, the domestic incumbent accounted for 46% of the total freight sector (based on train-tkm) and the non-incumbents for 38% (IRG 2021). This likely fostered an environment of competitive short-distance rail services.

Indeed, the country is (and has traditionally been) characterised by an extensive network of regional providers of rail freight services, of which there are varying owner structures (second interview with VDV). Some regional providers of complementary service are private companies (owner-managed), others are operated by local authorities or regional governments, still others are spin-offs of large industrial companies (so called *Werksbahnen* like *Chemion*, a railway spin-off from the chemical industry); there are even spin-offs from museum railways (second interview with VDV).[493]

Kreisbahn Siegen-Wittgenstein (KSW) is an example of a publicly owned regional rail service provider. KSW is owned by the district *Siegen-Wittgenstein*. Like many similar operators, they own and manage local infrastructure, but also offer rail haulage services. Regional feeder and distribution transport, mainly performed as subcontractor on behalf of DB Cargo, makes up about 70% of their rail freight activities.[494] KSW faces the exogenous challenges of declining single wagon transport volumes and reduced importance of goods like coal and iron ores that are traditionally often transported via rail. Consequently, it prioritises business development activities in sectors in which they traditionally served few, if any, clients. These ventures require investments, e.g. in new types of rolling stock or additional intermodal loading units.

A notable attempt to acquire new customers is the provision of *intermodal single-wagon services*, conducted in cooperation with DB Cargo. In a novel type of transport chain, a local brewery loads containers of beverage crates, mainly bottled beer, on trucks and transport them for a few kilometres to a local terminal, where they are transshipped on to single wagons. KSW then picks up the wagons and delivers them to the regional marshalling yard in Western Germany for assembly to full trains. Finally, DB Cargo hauls the full trains via its single-wagon transport system to Berlin, Hamburg and Bremen where the crates are distributed to beverage wholesalers.[495] Similarly, empties are delivered back to the brewery. After successful trial runs, KSW and its partners increased the transport volume, frequency and number of recipients. Nevertheless, soaring energy prices in conjunction with a reduction of subsidies evoked the shifted transport volume to be lower than the existing potential would allow. Importantly, this service competes with road transport as it connects decentralised origins and destinations that are typically not served by rail and does not threaten intermodal shuttles between metropolitan areas (interview KSW), but rather supplements it.

France, on the other hand, has traditionally maintained a more centralised system where the incumbent Fret SNCF, took a strongly dominant position in the market. However, in the last twenty years rail freight has been losing market share to road, due in part to SNCF's lack of responsiveness to market needs (interview with OFP). Additionally, structural factors have contributed to the decline. These factors are twofold. Firstly, France's

[492] The current number of active rail freight companies is around 231 (IRG 2020, IRG 2021 and Eurostat, variable „rail_go_total").
[493] The German industry association VDV provides a list of regional RU with different regional focuses: https://dms.vdv.de/sites/GV-KOOP/Seiten/Regio-EVU-Suche.aspx.
[494] The remaining 30% comprise primarily direct trains on short-distance, transporting steel, timber or intermodal loading units.
[495] See https://www.vdv.de/best-practice-intermodale-getraenketransporte.aspx.

deindustrialisation led to declining demand for heavy-goods transport.[496] Secondly, despite the entrance of several rail freight operators in the market, the process of liberalisation has destabilised SNCF and created a set of uncooperative players (Ministère Charge des Transports, 2021).

In light of this, and to improve the supply structure of regional rail freight services, since 2010, France has encouraged small- to medium-sized companies, called Opérateurs Ferroviaires de Proximité (OFPs)[497], to enter the market.[498] Since then, more OFPs have entered the market, and there are currently about 20 OFPs operating in the French rail freight sector. They concentrate on local services. Among others, they transport single-wagons or block trains to or from interchange points with long-distance RU. However, they rarely serve the French railway incumbent SNCF which prefers to source such services internally. In some cases, e.g. ports, OFPs also act as infrastructure managers, that are in charge of infrastructure maintenance, traffic circulation management, facility operation management and/or safety monitoring.

OFPs contributed to around 6% of the total rail transport volume (measured in tkm) in France in 2019 and had approximately 420 employees, operated in total about 80 locomotives and had an average annual turnover of about 22m EUR per firm.[499] OFPs are mostly private companies and do not receive State aid, meaning that they must be profitable or at least achieve a break-even to exist. OFPs are relatively small compared to the incumbent Fret SNCF, which, as of 2019, accounted for around 68% of the rail freight transport in France and had around 2,500 employees (IRG 2020, IRG 2021 and Eurostat).

In order to gain further insights into the business case of short-distance operations, the Consortium conducted an interview with RDT 13, a regionally established OFP, owned by the metropolitan area of *Aix-Marseille*.[500] RDT 13's rail division offers regional rail haulage services, for private and public customers, as well as maintenance and repair of infrastructure and rolling stock. Their haulage services, mostly demanded by public clients, are characterised by low profitability, mainly because of tough competition from road. In particular, RDT 13 stated that they had to suspend their single-wagon activities about two decades ago.[501] However, in an interview RDT 13 noted that their maintenance and repair services tend to be lucrative. RDT 13 showcases that publicly owned operators may ensure the provision of regional freight services to other RU where the market on its own might not. However, it also highlights the fact that State support may be required to ensure a commercially viable business.

In an effort to reduce urban congestion and pollution, *Aix-Marseille*, with the support of RDT 13, initiated a local freight service project in cooperation with several other partners. The project aims at boosting significantly the operations between logistics hubs in the region. The project foresees a gradual ramp-up on 4 routes between 2024 and 2026, jointly accumulating to 22 daily trains that would replace up to 500 trucks per day. One example is the *Fos – Saint Martin de Crau* connection. On that route, the current market price for transporting a container by truck on that route is 190 EUR, whereas the costs via rail are 269 EUR.[502] Hence, a successful project outcome requires State support for investments that would render the costs of rail competitive, including in rolling stock, 4

[496] The industrial sector represented only 10% of France´s total GDP in 2017, only half of Germany's (20% of GDP) in the same year.
[497] For more detailed information on OFPs, please refer to https://www.ecologie.gouv.fr/operateurs-ferroviaires-proximite-ofp.
[498] https://www.objectif-ofp.org/Lesofp-comment, and Thinieres (2021).
[499] https://www.objectif-ofp.org/Lesofp-comment, Thinieres (2021) and interview with OFP association.
[500] Please note that other OFPs are under private ownership.
[501] Interestingly, RDT 13 stated many clients are still interested in single-wagon activities, but RDT 13 cannot offer it competitively without additional State support, although they do not face competition from other short-distance operators in the region. They referred to discussions with long-distance RU on reviving such services, however.
[502] The figures refer to 2019. RDT 13 notes that the current trajectory of energy prices reduces the gap between costs of road and rail.

new terminals, and handling equipment. However, with an appropriate infrastructure in place, operating subsidies would not be required according to the interviewees from RDT 13.

An example of an initially locally operating railway spin-off that grew into an undertaking with a broader set of services is *LOTOS Kolej*, another short-distance operator the Consortium has interviewed. LOTOS Kolej has operated rail freight transport in Poland since 2002. Initially, it was a local shunting carrier for the major oil refining state-owned company Grupa Lotos S.A. Over time, it expanded its activities from the local Gdansk area to international transport, from serving the group internally to external customers and from petrochemical products to coal, metal ores, aggregates and containers. The main freight category is fuel. Apart from transport services, LOTOS Kolej offers forwarding services and services connected with railway siding operations, rental and maintenance of rolling stock and rail tanker cleaning.

Against the market trends, LOTOS Kolej operates single-wagon load profitably. This is possible thanks to the network of regular block trains operated between many locations across the country and creating many opportunities to attach a single wagon to a block train running in the desired direction. LOTOS Kolej has its own fleet of shunting locomotives and only rarely uses external providers of shunting services.

LOTOS Kolej stressed in the interview that the most important factor for the profitability of single-wagon transport is the availability of relevant infrastructure between the origin and the destination: marshalling yards, shunting locomotives, 750-meter long sidings with free capacity and generally track network allowing much higher average speed for cargo trains (up to 40-60 kph). LOTOS Kolej states that road transport exercises competitive pressure on single-wagon load, because trucks are typically faster than freight trains.

Annex 27 Intermodal transport types: cost structure of different TT

Table 93: Cost structure for intermodal transport with Gantry cranes and 20’ container

Gantry Crane 20' container	RAIL/ROAD (€ per LU)	IWW/ROAD (€ per LU)	SSS/ROAD (€ per LU)
Cost of loading unit	1.65	5.43	5.57
First road leg	87.35	87.35	87.35
First transshipment	32.33	53.56	48.53
Main leg	114.75	142.77	77.19
Second transshipment	32.33	53.56	48.53
Second road leg	84.72	84.72	84.72
Intermodal organisation	88.28	106.85	87.97
Total	441.4	534.24	439.86

Table 94: Cost structure for intermodal transport with Gantry cranes and 40’ container

Gantry crane 40’ container	RAIL/ROAD (€ per LU)	IWW/ROAD (€ per LU)	SSS/ROAD (€ per LU)
Cost of loading unit	2.30	5.43	5.57
First road leg	87.35	87.35	87.35
First transshipment[503]	32.33	53.56	48.53
Main leg	154.67	142.77	77.19
Second transshipment	32.33	53.56	48.53
Second road leg	84.72	84.72	84.72
Intermodal organisation	98.42	106.85	87.97
Total	492.10	534.24	439.86

Table 95: Cost structure for intermodal transport with Gantry cranes and semi-trailer

Gantry crane Semi-trailer	RAIL/ROAD (€ per LU)	IWW/ROAD (€ per LU)	SSS/ROAD (€ per LU)
Cost of loading unit	14.45	-	-
First road leg	87.66	-	-
First transshipment	36.42	-	-
Main leg	185.35	-	-
Second transshipment	36.42	-	-
Second road leg	83.42	-	-
Intermodal organisation	110.93	-	-
Total	554.66	-	-

Table 96: Cost structure for intermodal transport with Reach Stacker and 20’ container

Reach Stacker	RAIL/ROAD	IWW/ROAD	SSS/ROAD

[503] Based on the terminal costs per year as well as the total terminal handling capacity per year the different cost elements per transshipmenttransshipment are calculated. These are yearly values for the total terminal investment costs (building and equipment incl. planning), maintenance costs, energy costs, personnel costs as well as ground costs per transshipment.transshipment. The maintenance, energy and personnel costs per transshipmenttransshipment summed up provide the value for the total operational costs per transship-menttransshipment.

20' container	(€ per LU)	(€ per LU)	(€ per LU)
Cost of loading unit	1.96	5.36	-
First road leg	89.1	89.1	-
First transshipment	49.05	98.94	-
Main leg	117.13	173.91	-
Second transshipment	49.05	98.94	-
Second road leg	84.72	84.72	-
Intermodal organisation	97.75	137.74	-
Total	488.76	677.7	-

Table 97: Cost structure for intermodal transport with Reach Stacker and 40' container

Reach Stacker 40' container	RAIL/ROAD (€ per LU)	IWW/ROAD (€ per LU)	SSS/ROAD (€ per LU)
Cost of loading unit	2.64	6.8	-
First road leg	89.1	89.1	-
First transshipment	55.4	98.94	-
Main leg	158.39	185.88	-
Second transshipment	55.4	98.94	-
Second road leg	84.72	84.72	-
Intermodal organisation	111.41	141.09	-
Total	557.07	705.46	-

Table 98: Cost structure for intermodal transport with Reach Stacker and semi-trailers

Reach Stacker Semi-trailer	RAIL/ROAD (€ per LU)	IWW/ROAD (€ per LU)	SSS/ROAD (€ per LU)
Cost of loading unit	16.65	-	-
First road leg	87.66	-	-
First transshipment	58.06	-	-
Main leg	190.2	-	-
Second transshipment	58.06	-	-
Second road leg	83.42	-	-
Intermodal organisation	123.51	-	-

Total	617.56	-	-

Table 99: Cost structure for intermodal transport with hydraulic material handling crane and 20’ container

Hydraulic material handling crane 20’ container	RAIL/ROAD (€ per LU)	IWW/ROAD (€ per LU)	SSS/ROAD (€ per LU)
Cost of loading unit	2.02	4.,4	4.42
First road leg	87.35	87.35	87.35
First transshipment	59.14	60.87	52.19
Main leg	117.31	128.66	69.3
Second transshipment	59.14	60.87	52.19
Second road leg	84.72	84.72	84.72
Intermodal organisation	102.42	106.65	87.54
Total	512.08	533.26	437.72

Table 100: Cost structure for intermodal transport with hydraulic material handling crane and 40’ container

Hydraulic material handling crane 40’ container	RAIL/ROAD (€ per LU)	IWW/ROAD (€ per LU)	SSS/ROAD (€ per LU)
Cost of loading unit	2.79	5.44	5.58
First road leg	87.35	87.35	87.35
First transshipment	70.34	60.87	52.19
Main leg	156.8	139.79	77.27
Second transshipment	70.34	60.87	52.19
Second road leg	84.72	84.72	84.72
Intermodal organisation	118.08	109.76	89.83
Total	590.42	548.8	449.13

Table 101: Cost structure for intermodal transport with mobile harbour crane and 20’ container

Mobile harbour crane 20’ container	RAIL/ROAD (€ per LU)	IWW/ROAD (€ per LU)	SSS/ROAD (€ per LU)
Cost of loading unit	2.43	4.77	5.83
First road leg	87.35	87.35	87.35

First transshipment	84.05	83.82	74.44
Main leg	120.75	152.18	82.17
Second transshipment	84.05	83.82	74.44
Second road leg	84.72	84.72	84.72
Intermodal organisation	115.84	124.16	102.24
Total	579.18	620.82	511.19

Table 102: Cost structure for intermodal transport with mobile harbour crane and 40' container

Mobile harbour crane 40' container	RAIL/ROAD (€ per LU)	IWW/ROAD (€ per LU)	SSS/ROAD (€ per LU)
Cost of loading unit	3.34	6.15	7.3
First road leg	87.35	87.35	87.35
First transshipment	101.26	83.82	74.44
Main leg	165.92	165.34	89.8
Second transshipment	101.26	83.82	74.44
Second road leg	84.72	84.72	84.72
Intermodal organisation	135.96	127.8	104.51
Total	679.8	639.98	522.57

RoRO to/from ship Rolling trailers	RAIL/ROAD (€ per LU)	IWW/ROAD (€ per LU)	SSS/ROAD (€ per LU)
Cost of loading unit	-	-	3.15
First road leg	-	-	88.22
First transshipment	-	-	70.27
Main leg	-	-	260.04
Second transshipment	-	-	70.27
Second road leg	-	-	83.84
Intermodal organisation	-	-	143.95
Total	-	-	719.74

Table 103: Cost structure for intermodal transport with RoRo to/from ship and semi-trailer

RoRO to/from ship	RAIL/ROAD	IWW/ROAD	SSS/ROAD

Semi-trailer	(€ per LU)	(€ per LU)	(€ per LU)
Cost of loading unit	-	-	18.56
First road leg	-	-	89.98
First transshipment	-	-	53.26
Main leg	-	-	280.03
Second transshipment	-	-	53.26
Second road leg	-	-	85.59
Intermodal organisation	-	-	145.17
Total	-	-	725.84

Table 104: Cost structure for intermodal transport with RoRo to/from ship and casettes

RoRO to/from ship Cassettes	RAIL/ROAD (€ per LU)	IWW/ROAD (€ per LU)	SSS/ROAD (€ per LU)
Cost of loading unit	-	-	3.32
First road leg	-	-	96.98
First transshipment	-	-	76.26
Main leg	-	-	132.39
Second transshipment	-	-	76.26
Second road leg	-	-	88.22
Intermodal organisation	-	-	118.36
Total	-	-	591.81

Annex 28 Further results on price elasticities

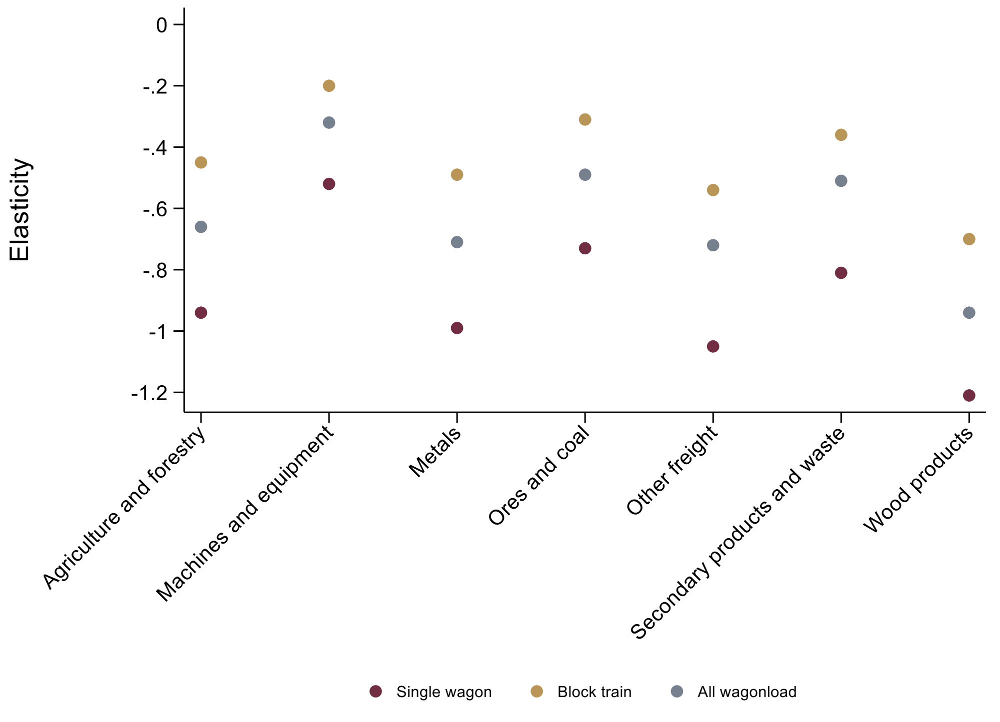
Table 105: Regression of elasticities by NST/R classification

Fixed Effects	Coefficient
IMC worldwide	0
Jourquin/Beuthe	-1.103**
Jourquin/Beuthe/Urbain	-0.403
Significance/de Jong	-1.730***
EU	0
Benelux	-0.403
nstr0	0

nstr1	-0.729
nstr2	0.508
nstr3	-0.145
nstr4	-0.59
nstr5	0.224
nstr6	0.043
nstr7	0.286
nstr8	-0.631
nstr9	-0.465
N	50

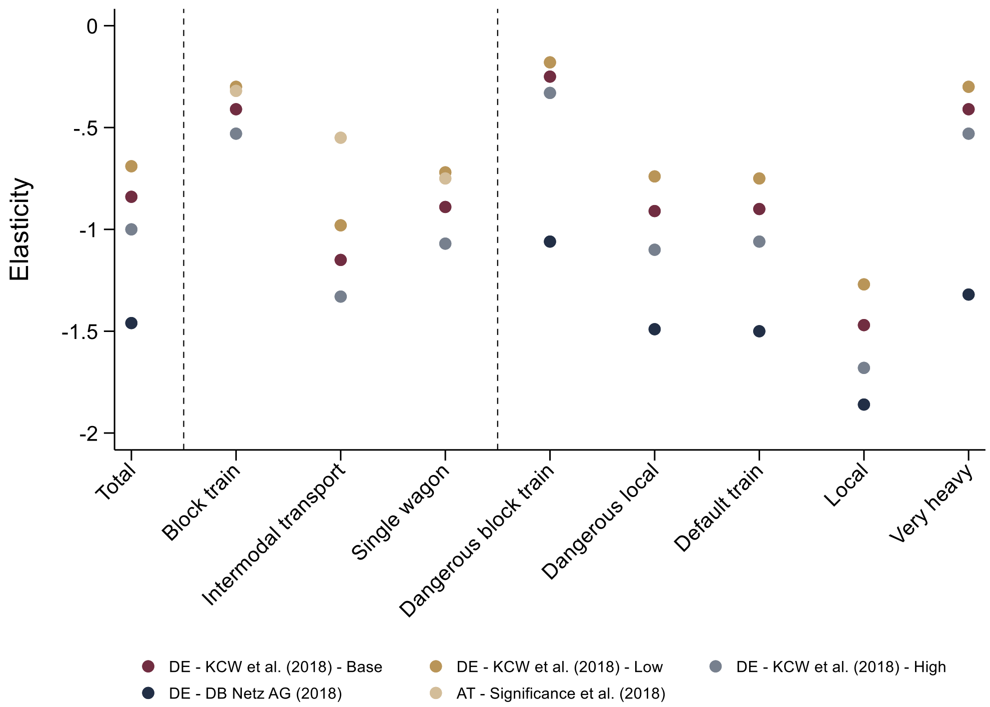
Source: The Consortium based on same sources as in Figure 37.

Figure 80: Price elasticity estimates of rail demand by train type and freight category



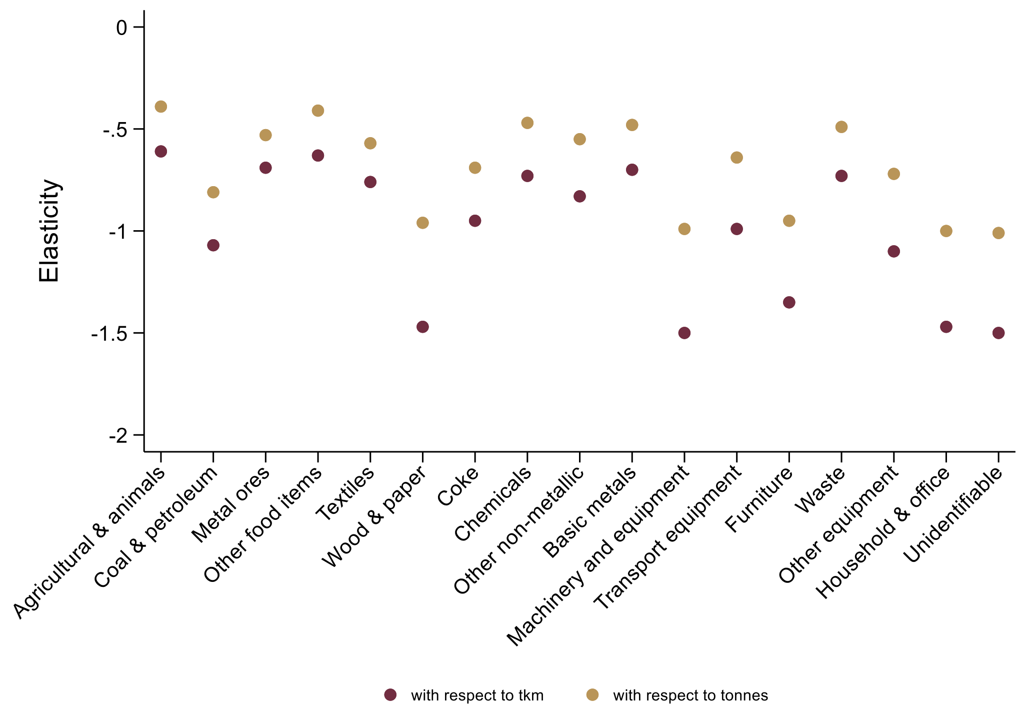
Source: KCW et al. (2018), visualised by The Consortium. All estimates with respect to modal choice.

Figure 81: Price elasticity estimates of rail demand in Germany and Austria



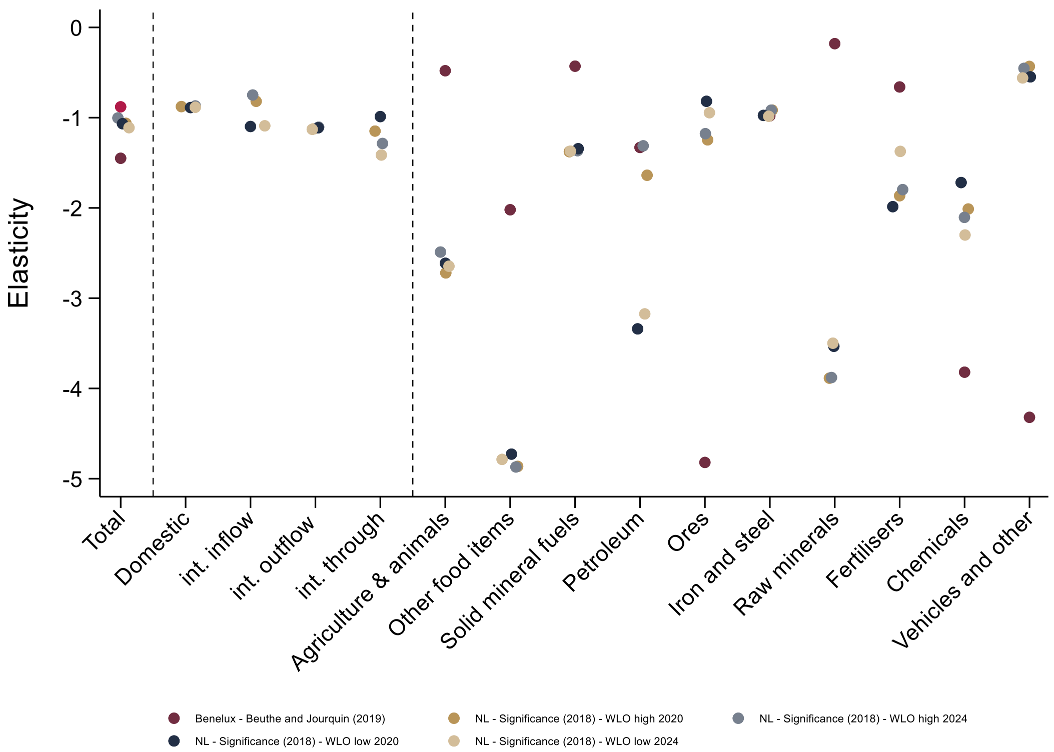
Source: see legend, compiled and visualised by The Consortium. All estimates with respect to modal choice.

Figure 82: Price elasticity estimates of rail demand by NST 2007 classification in Flanders



Source: Grebe et al. (2015), estimation for Flanders, visualised by The Consortium.

Figure 83: Price elasticity estimates of rail demand in the Benelux



Source: see legend, compiled and visualised by The Consortium. All estimates with respect to tkm.

European Commission

Final Report

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