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Foreign Firms & Dynamic Indicators of Competition

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Abstract: The tools economists and policymakers use to assess market competition often face fundamental limitations in their standard applications. For example, measuring market concentration without accounting for the largest firms provides limited insight. Similarly, any assessment of market power becomes incomplete if we do not identify which firms wield it and how long they can wield it for. This thesis demonstrates how overlooking these issues can lead to inaccurate conclusions about competition within a market. Specifically, we show that foreign firms frequently dominate as the largest firms within a market, and their accurate inclusion significantly raises the calculated level of market concentration. Additionally, we find that churn at the upper end of the sales distribution—the ability of firms to enter or exit the top ranks by market share—has been declining. This suggests that the firms with the greatest market power are maintaining their leading positions longer. Our analysis also reveals a relationship between market churn and other competition indicators. Highly concentrated markets and those with greater average markups tend to exhibit lower levels of churn. We further observe that large foreign firms tend to retain their top positions more persistently than domestic firms. By examining factors that influence a firm's stability at a given rank, we find that higher productivity and markups contribute to sustaining a firm's high market share.

Keywords: Producer Concentration, Seller Concentration, Competition, HHI.

JEL classifiers: International Trade, Industrial Organisation.

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Introduction

This thesis aims to bridge a key gap between the literature on international trade and industrial organization (IO), ultimately providing policymakers with more nuanced measures of market competition that incorporate the roles of foreign firms and firm persistence over time.

Our research is motivated by recent indications that market power may be increasing globally, a trend sparking significant debate among researchers and policymakers (De Loecker, Eeckhout, and Unger 2020a, Philippon 2019, Autor et al. 2020, Weche and Wambach 2021, Shapiro 2018, Shapiro and Yurukoglu 2024). Concentration, one of the most commonly used indicators of competition, appears to be rising in the US and several developed economies, including the UK (OECD 2018, Furman and Orszag 2018, Rossi-Hansberg, Sarte, and Trachter 2021, Barkai 2020, Covarrubias, Gutiérrez, and Philippon 2020, CEA 2016, Tomlinson and Bell 2018, Corfe and Gicheva 2017). However, many studies overlook the impact of foreign firms, which can often be the largest players within these markets.

The dominance of large firms in international trade is well documented (Bernard, Jensen, et al. 2018, Castellani, Serti, and Tomasi 2010, Mayer and Ottaviano 2007, WTO 2008, Freund and Pierola 2015). For instance, Amiti and Heise 2021 illustrate that, in the US, accounting for imports and excluding exports significantly lowers the effective level of concentration consumers face. However, whether this dynamic holds for smaller economies remains uncertain. We address this gap by distinguishing between *Seller* concentration (firms providing products to consumers) and *Producer* concentration (firms producing goods), showing that for the UK, including imports can markedly increase market concentration levels.

High concentration, however, does not inherently signal weak competition; it must be analysed alongside other indicators. One such measure, markups (the gap between price and marginal cost), has gained prominence with improved data quality and estimation methods. But a critical aspect of market power—its persistence over time—remains under explored. High concentration is less concerning if the top firms frequently change. Similarly, a market where

one firm can consistently set high markups over time would be less competitive than one where different firms occasionally hold this position. To address this, we examine the interplay between concentration, markups, and churn (the rate at which top firms change). Additionally, we analyse the relationship between markups and a firm's ability to maintain a high market share.

Our analysis, covering 230 four-digit UK markets from 2007 to 2019, focuses on two factors: the presence of foreign firms and churn among top firms. Chapter 1 introduces our concepts of *Seller* and *Producer* concentration, providing methods for estimation in the absence of comprehensive firm-level data. We find that in many UK markets, including imports and excluding exports reveals significant levels of concentration that meet conventional antitrust thresholds. Chapter 2 refines this analysis by directly measuring seller concentration, showing how foreign firms dominate the top of the sales distribution and exert a concentrating effect. Chapter 3 investigates churn among the largest firms, revealing a trend of reduced turnover over time. We find that churn tends to decrease in markets with higher markups and analyse the firm-level factors that contribute to a company's ability to retain a top position. In chapter 4, we investigate one aspect of churn in which a firm large firm enters a market and immediately assumes a significant market share. One situation in which such a disruption might occur is a large multinational firm opting to enter a the market for a new country. We consider this large firm entry in the context of a mixed market structure where large oligopolistic firms compete with a fringe of monopolistically competitive enterprises. In doing so we represent the first attempt at empirically investigating these mixed market models and find some indication that large incumbents are more affect by large entry than the fringe and that the effect is stronger when the firm is foreign.

Contents

Chapter 1

Seller v. Producer Concentration

Abstract: We highlight a potential measurement issue in the use of concentration as an indicator of competition, a common practice in discussions on trade and competition policy. By defining *Seller Concentration* in opposition to *Producer Concentration* we highlight how overlooking the role of imports and the presence of foreign firms can lead to incorrect conclusions about the competitive landscape within a given industry. We also present a 'bounds approach' to estimate Seller Concentration in the absence of perfect data. We use this method to analyse 119 four-digit UK industries between 1998-2018 and find that concentration has likely not increased as much as previously thought and the incidence of industries which would be defined as 'concentrated' or 'highly concentrated' using conventional anti-trust policy definitions are much reduced.

Keywords: Producer Concentration, Seller Concentration, Competition, HHI.
JEL classifiers: International Trade, Industrial Organisation.

1.1 Introduction and motivation

[1] Recent years have seen a growing body of empirical research and policy interest question whether 'concentration' is on the rise [2]. As measures of concentration, such as the Herfindahl-Hirschman Index (HHI), are frequently utilised as benchmarks for evaluating levels of 'competition', there has arisen a growing concern that these metrics suggest a potential weakening of competition. However, there are serious doubts, which we share, about the role of traditional indices of concentration in measuring competition. The link between concentration and competition is complex, but given how often policy makers and other economists cite concentration

[1] This chapter is based upon a working paper published with Steve Davies, to whom I am extremely grateful for his help with this piece and much much more, Steve passed away on 4 August 2022. He is sorely missed.

[2] For the US see Autor et al. 2020, Barkai 2020, Covarrubias, Gutiérrez, and Philippon 2020, Grullon, Larkin, and Michaely 2019, and Van Reenen 2018. For the UK see Corfe and Gicheva 2017, Savagar et al. 2024 and Tomlinson and Bell 2018 However evidence in Europe and elsewhere is more mixed. See Bajgar, Berlingieri, et al. 2023, Cavalleri et al. 2019 and OECD 2018.

figures when discussing competition, we must ensure there is clarity and precision in these metrics for them to remain useful. Put simply, if we continue to measure concentration incorrectly, why measure it at all?

Stephen Davies 2021 summarises a range of these uncertainties — from conceptual queries such as the nuanced definition of 'competition' to more technical, and practical challenges inherent in data interpretation. While clarification on each of these is needed, this paper focuses on just one: elucidating the methodology for adjusting an index measuring the concentration of domestic producers to account for the influence of imports and exports on the market. Less prosaically, the underlying issue is what does a measure of producer concentration in an industry tell us about the concentration of sellers in its associated market?

With the exception of Amiti and Heise 2021, most measures of concentration in the literature have largely ignored this issue, employing measures derived from business registers, which invariably estimate domestic producer concentration, but competition economists and policy makers should be more focused on competition between the main sellers. Especially for trade-reliant countries, competition from imports often matters for market power, while quite often a sizeable proportion of the home firms' turnover is exported and has no direct impact on competition within the domestic market.

It is worth noting there are important conceptual reasons why concentration, even appropriately measured, does not necessarily reflect the intensity of competition in a market. The familiar endogeneity issue which first surfaced in the old Structure-Conduct-Performance (SCP)/Chicago debates of 50 years ago and has remained ubiquitous ever since, continues to remind us that high concentration is not necessarily indicative of competition-dampening market power[3]. Instead, it could be the consequence of intense rivalry, with large market shares the reward for innovation and efficiency. We sidestep this fundamental issue in this paper, and we are careful not to equate concentration with competition: they are not necessarily inversely related. This is not to deny that concentration should remain one of the most important metrics at our disposal – it is likely to be a key indicator of the outcome of the competitive process as well as, in turn, a determinant of those outcomes.

Against this backdrop, the paper has two objectives. The first is to establish a framework which allows us to combine business register data on production within a country and trade data, recognising the reality that, in most countries, firm-level information on imports and exports is

[3]See the seminal paper by Bain 1951 and subsequent literature, including Demsetz 1973. Werden 2021 provides an overview of the history of this debate and how it can shed light on the current discussion.

not available[4]. This framework must recognise that it is not only the magnitude of the trade flows at the market level which matters, but also the market shares of the firms undertaking the trade. For example, in some cases imports might merely be the supply from a price-taking competitive fringe, but, in others, there may be only a few potentially dominant importers. The secondary goal is to leverage this framework for the purpose of generating illustrative statistics. The United Kingdom will be utilised as a case study to provide tangible insights into the potential scale of trade adjustments concerning concentration. Our approach aims to highlight the change in our understanding of trade and competition in a given market that can occur when we measure concentration more appropriately. Here, precisely because no theory will fit all, and given the absence of firm-level trade data[5], we opt for a cautious approach, in which we calculate plausible lower and upper adjustments to producer concentration which allow for very different conjectures about the concentration of importers. Although the range between the lower and upper bounds turns out to be wide, it is sufficiently narrow to allow two important qualitative inferences about the importance of distinguishing producer and seller concentration. First, our data suggests that while producer concentration has grown, on average, consistently for much of the last two decades, seller concentration has not. Second, the number of individual industries which can be labelled 'concentrated' in terms of producers is much reduced when concentration is measured in terms of sellers.

Our contribution to the literature is three-fold. First, we define *Seller Concentration* as a more appropriate metric in the study of market concentration, providing some expositional clarity on how to more accurately measure the effective level of concentration faced by consumers and firms. In doing so we provide an improved methodology for measuring concentration in the absence of universal firm-level data (as in Amiti and Heise 2021). Second, we show that in some industries concentration may be higher than previously thought as the dominance of foreign firms is overlooked. Third, we show that for UK manufacturing, concentration may likely be significantly lower than previous studies have suggested. Taken together, the second and third points above show how this improved measure can completely change our understanding of the level of, and trends in, concentration. The implications of this are that not only are we incorrectly labelling some markets as concentrated, which could lead to unnecessary attention

[4]Throughout, we use the term 'production' as a shorthand for the turnover of domestic firms' domestic production which is what is typically reported in business registers or censuses.

[5]Even the CMA 2020 in its official statistical summary of the State of Competition in the UK reports only the sparsest of data on trade – merely for aggregate imports at the very aggregate two-digit standard industry classification (SIC) level. Details on the UK's Standard Industrial Classification system are provided by the Office of National Statistics here.

by policymakers, but that we may in fact be overlooking markets that are facing high levels of concentration. When considering where to investigate issues of competition, policy makers and economists often use concentration in their first round of analysis to identify potentially noncompetitive industries that should receive a more detailed investigation. This is often because concentration is one of the easier metrics to measure. However, if *Producer* rather than *Seller* concentration is what is measured, the list of potentially noncompetitive industries will be incorrect.

The organisational structure of the paper unfolds as follows. Section 1.2 establishes the context through a literature survey, delving into recent empirical studies on concentration trends and examining a select number of prior investigations that specifically explore alternative methodologies for adjusting concentration, including cases where adjustments account for trade influences. Section 1.3 employs a case study of the UK car industry/market, which is unusually data-rich at the firm level, allowing us to evaluate producer and seller concentration from primary sources. It shows how far the two may differ. Section 1.4 sets out our framework - a decomposition which converts an index of producer concentration into seller concentration. This reveals that there can be no general prediction on the impact of trade on concentration: it depends on the relative concentrations of the importers and exporters. More positively, however, it allows us to identify lower and upper bounds on the magnitude of the adjustment. Section 1.5 describes our database. Given the very imperfect data currently available for the UK, this represents our best efforts to combine the key Business Register with the trade classifications of imports and exports. Section 1.6 applies the decomposition to these data to derive a picture of the current state and evolution of seller concentration in the UK from 1998 to 2018. The results show that the impact of incorporating trade statistics into domestic measures of concentration could be sufficiently large to overturn the evidence of rising and prevalent concentration for at least a significant subset of manufacturing industries. Section 1.7, stresses the limitations of the piece and concludes.

1.2 Relevant literature

1.2.1 Competition and concentration concerns in the US and Europe

Renewed concerns over weakening competition took hold in the US with the work of Furman and Orszag 2018 who found that in roughly 75% of two-digit industries, the largest 50 firms had con-

centrated their market share between 1997 and 2007. In the study conducted by Grullon, Larkin, and Michaely 2019, findings suggest a correlation between the rise in concentration and elevated profit margins, without concurrent improvements in operational efficiency. These observations prompt a broader inquiry into the potential erosion of competition, a matter of considerable concern for policymakers. This issue is underscored by the interest shown by notable entities such as CEA 2016 and Akcigit (2021). This assertion gains further strength from disconcerting statistics concerning markups and market power on a broader scale. Particularly noteworthy is the research conducted by De Loecker, Eeckhout, and Unger 2020b, supplemented by insights from Diez, Fan, and Villegas-Sánchez 2021 and Gutiérrez and Philippon 2017. Collectively, these studies underscore the pervasive nature of the issue and accentuate its significance in the current economic landscape. Some go so far as to interpret this as evidence that, in the US at least, markets and competition authorities (CAs) are not functioning well, especially concerning lax merger control and antitrust enforcement (see Philippon 2019 and Shapiro 2019). However, some are more cautious, highlighting the plethora of issues that exist with the given indicators of competition (see Berry, Gaynor, and Morton 2019 and Shapiro 2018).

As one of the most common competition indicators, several papers have found evidence of increasing concentration within the US and Europe, with numerous explanations proposed. Bajgar, Criscuolo, and Timmis 2021 chronicle a surge in the period from 2002 to 2014, contending that investments in intangibles, particularly software, have empowered major corporations to expand their market share. However, Bajgar, Berlingieri, et al. 2023 present a nuanced perspective, demonstrating an upward trajectory in both manufacturing and non-financial services. Their argument posits that the overall escalation is not solely attributable to digitally intensive sectors, introducing a layer of complexity to the narrative. Autor et al. 2020 takes this one step further and suggests that the nature of the competitive landscape has changed dramatically. They argue industries are increasingly characterised as 'winner takes most' in large part due to technological change. As one example, they argue the diffusion of new competitive platforms has made price/quality comparisons easier, therefore it is easier for the 'best' product to be found.

While concentration appears to have increased in both the US and Europe, what it means for competition and the underlying causes may be quite different. There are both significant asymmetries between the US and European markets in general and significant heterogeneity between individual European markets. For example, trends in markups post-financial crisis,

between European countries are somewhat mixed and appear much lower than in the US (Weche and Wambach 2021). Bighelli et al. 2023 note that while European concentration appears to have increased. It is reflected by an increase in productivity and allocative efficiency, with minimal change in markups. While Koltay, Lorincz, and Valletti 2023 suggest European market power has risen with concentration. Some have found no evidence of increasing concentration in Europe (see Valletti et al. 2017 and Cavalleri et al. 2019).

1.2.2 Measuring concentration at the right level

As mentioned earlier, what concentration can tell us about the nature of competition in a market is not always clear, and yet evidence of high concentration is often prioritised in discussions on competition by policy makers (see for example Koltay, Lorincz, and Valletti 2023 and Boushey and Knudsen 2021). The matter is further complicated by how concentration measures are calculated in practice. While this debate is not new, recent advances in data availability have highlighted the issue. As noted by Werden 2021 evidence of increasing concentration in the US relies on excessively aggregated data, which can impart a substantial downward bias in market concentration levels and can impart a substantial upward bias in market concentration trends. This phenomenon is underscored by Benkard, Yurukoglu, and Zhang 2021, whose study gauges concentration at the product/market level. Notably, their findings reveal that although concentration levels remain elevated, there has been a discernible decrease in these levels since 1994. This nuanced perspective adds depth to the understanding of concentration dynamics within the examined context. In a similar vein, Rossi-Hansberg, Sarte, and Trachter 2021 find that between 1990-2014 national concentration appears to have increased, but local concentration has fallen. Given that many markets are constrained geographically, local concentration is therefore a better indicator of competition. As noted by the authors, a coffee shop in Manhattan does not compete with one in Seattle. At the other end of the spectrum, if we focus solely on domestic concentration we will inevitably overlook international competition. Freund and Sidhu 2017 provide a first attempt at measuring global concentration at the two-digit level and find evidence of concentration decreasing, attributing some of this to growing competition from emerging markets, especially China.

1.2.3 International trade and concentration

There exists a large theoretical and empirical literature at the interface of Industrial Organisation and International Trade, which explores the possible causal relationship between import competition and concentration. An extensive survey of this is unnecessary here given the objectives of the current paper, but two observations from this literature merit attention: the first is the so-called 'Two and a Half Theories of Trade' and the lack of consideration for large firms in trade theory; the second is ambiguity surrounding the mechanisms behind the impact of imports on domestic markets.

From a theoretical perspective, the study of international trade is dominated by two paradigms, the theory of comparative advantage based on perfect competition, and the theory of product differentiation and increasing returns based on monopolistic competition. Analysis of the role of large firms in international trade has not garnered as much attention, which has given rise to what P. J. Neary 2010 referred to as the 'Two and A Half Theories of Trade'[6]. The differences between these paradigms in how they characterise foreign firms and the implications for how they will impact markets and competition. For our work in this paper, two of the more relevant works are that of Shimomura and Thisse 2012 and Parenti 2018. Shimomura and Thisse model a hybrid market combining elements of oligopoly and monopolistic competition. They characterise a domestic market with an exogenous number of large firms and a monopolistically competitive fringe determined by free entry and exit. In this model, when faced with entry by a large (foreign) firm, the fringe shrinks, competition increases, and welfare improves. Parenti expands on this hybrid approach by allowing large firms to decide how many products to offer. Trade liberalisation can then increase or decrease welfare depending on trade costs, and the number of trading partners/large foreign firms. Finally, we would be remiss to not mention Cowling, Yusof, and Vernon 2000 who pointed out the issue we are attempting to solve over 20 years ago. For a sample of transportation industries within the UK, they demonstrate how concentration has been incorrectly measured due to an assumption that all imports are competitive and thus a solely deconcentrating force. With that said, empirical work measuring the size and strength of foreign firms within domestic markets is severely lacking. Our work then serves as a contribution to this literature in attempting to assess how much potential power foreign firms may possess.

[6]Head and Spencer 2017 also discuss the fluctuating interest in this third paradigm and discuss the reasons why oligopoly in international trade has not received as much attention but is now undergoing somewhat of a resurgence.

On the empirical side, many studies have found imports to boost competition among domestic firms but the exact mechanism behind this is often unclear (see for example De Loecker and Pinelopi Koujianou Goldberg 2014, Pavcnik 2002 and Syverson 2011). However, the effect of foreign competition on domestic firms does not necessarily reflect the wider impact on the market in question. Arkolakis et al. 2019 show it is 'perfectly possible for domestic and foreign markups to move in (following trade liberalisation)' (p.77). To truly understand the competitive landscape we must fully incorporate foreign firms into any analysis. Our approach of using seller rather than producer concentration is one example of how this kind of omission can be avoided.

1.2.4 The UK picture

Britain has not been immune to questions over weakening competition (The Economist 2018), leading the Competition and Markets Authority (CMA 2020) to commission a comprehensive report on competition across the economy, for which a large portion of the evidence relies on trends and levels of concentration, using data from the comprehensive Business Structure Database (BSD) on the domestically generated turnovers of the full population of firms in the UK.

In addition to the CMA report, several other recent studies have reported evidence on the evolution of concentration levels in the UK, including Tomlinson and Bell 2018, Corfe and Gicheva 2017, Savagar et al. 2024 and Stephen Davies 2021. Most also use the BSD data, and the consensus, although not unanimous, finding of these studies is that average levels of concentration increased somewhat in the first 10-15 years of this millennium before levelling off. The work of Corfe 2018, conducting a number of case studies using primary sources, also confirmed prevailing high levels of concentration.

In a companion paper, Stephen Davies 2021 calculates concentration measures fairly representative of the studies referenced above, measuring average HHI across 361 four-digit industries in the UK (see his Figure 1 and Table 3). Davies also reports the distribution of HHI across industries. In terms of conventional yardsticks used in the UK, over 30% qualify as concentrated' (HHI > 1000), of which nearly half are 'highly concentrated' (HHI > 2000); the number of 'highly concentrated' industries doubled between 2000 and 2018. Bearing in mind that the typical four-digit industry will comprise a large number of Anti Trust Markets (ATM), which will typically be much more concentrated than the four-digit industry itself (Davies, 2021, section 4), it is fair to conclude that the UK is now characterised by widespread concentration,

after an extended period of sharply increasing concentration levels.

But the crucial issue is that this and all other UK evidence relates only to producer concentration, with no adjustments having been made for the impact of trade. As already mentioned, one of the objectives of the current paper is to explore how robust are these findings once the data have been converted into assessments of seller concentration.

1.2.5 The need for 'Seller Concentration'

Outside the UK, there have been a handful of studies, all for the U.S., which have addressed the measurement of importer concentration. At one extreme, Covarrubias, Gutiérrez, and Philippon 2020 employ an adjustment which echoes the treatment of imports in a few early SCP empirical studies (see, for example, L. Esposito and F. F. Esposito 1971). This is to simply inflate the denominator of the concentration ratio to include imports while leaving the numerator unchanged[7]. By definition, this attributes to imports a deconcentrating and, by implication, pro-competitive role. At the other extreme, an adjustment employed by Autor et al. 2020 assumes individual importers with potentially considerable market shares. While they do not have access to a firm-level breakdown of imports, they can disaggregate imports into six broad country region-groups of origin [8]. They assume that there is a sole importer from each of these regions, and if one or more of these is sufficiently large, they become one of the leaders[9]. We think of this assumption as a 'regional monopoly'. The issue with this approach is all firms from region X are taken as a single entity, leading to a clear upward bias in the concentration measure.

Feenstra and Weinstein 2017 (Table 2) employ an intermediate methodology. While they do not have universal firm-level import data, they do have access to HHI indices for exporters to the US at the country level. These are then averaged, for each product, along with the US domestic HHI to generate a weighted average HHI for each industry[10]. For many countries,

[7]For instance, if CR8 = 60%, industry domestic turnover is 100 and imports are 20, trade-adjusted CR8 would be 60/120 = 50%: implicitly assuming that no single importer is sufficiently large to be amongst the leading sellers in the market.

[8]The six groups are: Canada, Mexico/CAFTA, China, low-income countries, eight developed countries and the rest of the world.

[9]Their preferred concentration measures are concentration ratios, e.g. CR4, and so, in this case if imports from a given country-region, say Canada, are greater than the market share of the fourth largest domestic firm, 'Canada' replaces that firm and C4 is increased by an amount equal to the difference between imports from Canada and the domestic turnover of the fourth largest US firm.

[10]If our reading is correct, their weighted average HHI for each product is similar, but not identical to our index of seller concentration (HS). Their weights are the simple country-shares, while we show that, if the aggregate index is to be defined as an HHI of all sellers in a market, the weights should be the squared country-shares which they then use in subsequent work on welfare and markups.

however, access to these foreign exporter HHI figures may be unavailable or not appropriate[11]. While our approach would still be feasible, as it does not require so granular data from other countries.

The work of Bonfiglioli, Crinò, and Gancia 2021 deals explicitly with the measurement of importer concentration. For the US they find that concentration among US importers has fallen, and is lowest for imports from Western Europe, South East Asia, India and China. The study is limited in that, while the authors do have access to firm-level import data, they do not incorporate export or home sales data and so are unable to measure what we define as seller concentration. They also only have import data for sea shipments and therefore not the full universe of firms (a problem shared by Feenstra and Weinstein).

In each of the above approaches, the authors, like us, do not have access to individual importing firms' share of the domestic market, but in a very recent paper, Amiti and Heise 2021 report results based on their access to comprehensive confidential data from the US Census Bureau on the sales of individual importing firms. As they point out, their study is therefore the 'first to include all of the foreign firms' sales to measure concentration in the US' (p.2). Their estimates are at the five-digit NAICS industry level at five yearly intervals over the period 1992-2012 and establish various stylised facts, the two most relevant for our purposes are that (i) 'market concentration (measured with concentration ratios) in US manufacturing, adjusted for foreign firms, remained stable on average between 1992 and 2012', and (ii) 'foreign firms have on average increased their presence among the top 20 firms, but their share in the top 20 remains low. This study is, in terms of data availability, the 'effective gold standard', which unfortunately we are unable to emulate for the large portions of UK economy (and also, one suspects, for most other countries), given what is currently available at least in the near future. Moreover, there are no reasons for assuming that their stylised facts will also apply to the UK, given its greater historical reliance on trade, extensive European integration, and then subsequent withdrawal from the European Union).

1.3 An example: the UK car industry and market

This section briefly illustrates the difference between the concentration of sellers in a market and the concentration of producers in a domestic industry. It uses the car industry as a case study,

[11] As noted by the authors, their data covers only the largest exporters by sea which for the US covers most imports, however, this may not be the case in other countries especially for example within the EU.

Table 1.1: Concentration in UK Car Market, 2018.

	Producers	**Sellers**	**BSD**
HHI	2190	967	1837
C5	93.2%	61.6%	78.8%
Export Share	81%		
Import Share		88%	

Source: SMMT 2019.

partly because firm-level data are readily available online (SMMT 2019), and partly because it is one of the UK's most trade-intensive intensities: in 2020 it accounted for 7% of all UK's exported goods and 6% of all imported goods.

In the UK SIC, car manufacturing is recorded as 2910, and the public Business Structure Directory (BSD) reports the HHI as 1837 and the top five-firm concentration ratio (C5) as 78.8% (see Table 1.1). In our terminology, these are indexes of producer concentration. Access to individual firm shares is restricted for confidentially but in this particular case, the trade body regularly publishes detailed information about the volumes of production and sales for individual firms.

The five largest producers in the UK, JLR, Nissan, PSA, BMW, Honda and Toyota, are subsidiaries of foreign-owned multinationals, and over 80% of their production is exported. According to our calculations, the HHI of producers (HP) is 2190 and the top five-firm concentration ratio is 93.2. Within the domestic UK market, on the other hand, most cars are imported (88%); and only three of the top ten models are produced in the UK. The top five selling firms, VW, Ford, BMW, PSA and Mercedes source their sales exclusively or mainly by imports and account for 62% of the market and the HHI of sellers (HS) is 967.

From this industry, we learn two noteworthy lessons. First, the official BSD estimates underrecord the level of producer concentration, presumably it applies an industry definition which includes other related supply or adjacent markets, while our definition is stricter and confined exclusively to finished cars. Second, and much more important, producer concentration, whether estimated by us or in the BSD, is significantly higher than seller concentration (the HHI is twice as large). The high level of import penetration, 88% acts to reduce the level of concentration in the market despite the high level of concentration among the producers.

Our argument in this paper is that *Seller* concentration is the more appropriate indicator of competition for competition policy as it pertains to the goods or services that are supplied to

consumers within a given economy. The issue is that *Producer* concentration is often what is reported, as a result if there exists a significant difference between the two (as is the case in this example) then policy makers will likely make incorrect inferences on the state of competition in a market. In this case, the high producer concentration may encourage policy makers to act to preserve / restore competition, when in actuality, the market is not concentrated when we look at sellers.

1.4 A framework for converting Producer to Seller Concentration

The above example benefited from the availability of published firm-level data, but, unfortunately, this is not the case for the overwhelming majority of industries and markets. In the UK at present, we only have public access to data at the industry level to summary concentration statistics such as the HHI and C5 on the production side and data at the commodity level for trade. This section sets out our methodology in the absence of such firm-level data. We first present a formal decomposition which links producer and seller concentration and leads to a proposition which suggests that seller concentration will be typically lower than producer concentration. It also establishes the key role of 'importer concentration'. Unfortunately, the absence of firm-level trade data prevents us from accurately calculating this, and in the second part of the section we develop a bounds approach which fully utilises the data we do have – at the industry (more correctly commodity) level for annual imports and exports, in total and by country of origin/destination[12] - to derive special cases in which importer concentration takes its minimum and maximum levels. These are then taken to the data in the following sections.

1.4.1 A decomposition

We first present a decomposition which can be used, given appropriate data, to convert an index of producer into seller concentration; we illustrate with the HHI partly because it is the most widely employed index of industrial concentration and partly because it is easily decomposed statistically. It distinguishes four separable effects, depending on: (i) the magnitude of exports, (ii) the concentration of exporters, (iii) the magnitude of imports and (iv) the concentration of importers. Additional details on the decomposition can be found in the appendix (1.7).

[12]The trade data can also be disaggregated by national destinations of exports, but this is superfluous for our purposes here.

Box 1 - Key Terms

Notation for a given product/market

Concentration indexes (0 < HHI < 1)

- HS HHI concentration of all sellers
- HP HHI concentration of domestic producers
- HDS HHI concentration of domestic sellers
- HM HHI concentration of all importers
- HM_ω HHI concentration of importers from country ω, $\omega = 1 \ldots \Omega$
- HGD geographical HHI concentration of imports (across countries of origin).

Monetary measures (£)

- P domestic production
- X exports
- M imports.
- T total sales = $(P + M - X)$

Shares

- x export intensity = X/P
- m import penetration = M/T
- μ_ω country ω's share of total imports = M_ω/M.

Note first that the HHI index of 'size' in a population comprising several groups can be decomposed into the weighted average HHI within the groups, where the weights are the groups' squared shares of the population size. So, in this case, identifying two types of sellers in the domestic market, domestic sellers and foreign importers, market seller concentration is:

$$\text{HS} = (1 - \text{m})^2 \text{ HDS} + \text{m}^2 \text{ HM}. \tag{1.1}$$

Similarly, if imports are sourced from Ω foreign countries, the concentration of aggregate imports is the weighted sum of the concentration of importers within the source countries:

$$\text{HM} = \sum_{\omega=1}^{\Omega} \text{HM}_\omega \ \mu_\omega^2. \tag{1.2}$$

Note that the distribution of the weights in Equation 1.2 can be thought of as an index of geographic dispersion in the sources of imports:

$$\text{HGD} = \sum_{\omega} \mu_\omega^2. \tag{1.3}$$

HGD varies between $(1/\Omega)$, if imports are sourced in equal magnitudes from all foreign countries, to 1, if all imports come from a single country.

Second, we introduce a simplifying assumption, largely for expositional clarity[13]:

A1 - Proportionate exporting All domestic producers export the same proportion (x) of their production. If so, each firm's share of the industry total remains unchanged, and the HHI of domestic sellers are identical to the HHI of domestic producers:

$$\text{HDS} = \text{HP}. \tag{1.4}$$

Substituting Equation 1.4 into Equation 1.1 leads to:

$$\text{HS} = (1 - \text{m})^2 \text{ HP} + \text{m}^2 \text{ HM}. \tag{1.5}$$

Proposition 1 *(i) Seller Concentration (HS) will be lower than producer concentration (HP) unless importers are 'considerably' more concentrated than domestic producers and the market*

[13]There is some evidence to suggest larger firms export proportionately more (See Freund and Pierola 2015 and Bernard, Jensen, et al. 2018). If this is the case then HP > HDS. In turn, this would reduce our estimates of HS below. Our proportionality assumption is a reasonable first approximation in the absence of detailed firm level data.

is highly trade intensive, (ii) As trade intensity increases, producer concentration becomes an increasingly weaker indicator of seller concentration.

for (i), HS > HP only if $\left((1-\mathrm{m})^2\text{–}1\right) + \mathrm{m}^2(\mathrm{HM}/\mathrm{HP}) > 0$, i.e., if $(\mathrm{HM}/\mathrm{HP}) > ((2-\mathrm{m})/\mathrm{m})$. Note that $(2-\mathrm{m})/\mathrm{m} > 1$ for all $\mathrm{m} < 1$ and rises at an increasing rate as m falls below 1. For (ii), recall that $\mathrm{m} = \mathrm{M}/(\mathrm{P}+\mathrm{M}-\mathrm{X})$, which is increasing in both X and M, for given P, and increasing m reduces the weight of HP as a determinant of HS in Equation 1.5.

1.4.2 Implications

Both parts of the proposition may be somewhat intuitively obvious but nevertheless merit the emphasis of a formal proposition, if only to suggest caution when interpreting the evidence of the previous literature, increasing producer concentration in a period of increasing trade intensity does not necessarily imply the same for seller concentration. Part (ii) of Proposition **??** shows that producer concentration becomes an increasingly less reliable signal of what is happening to the seller concentration in a world of rising trade intensity, and part (i) requires quantification on how to interpret 'considerably', and it is to this that we now turn.

1.4.3 A Bounds Approach when importer concentration is unknown

Given that, along with nearly all previous studies except for a very few US cases, we do not have access to individual importer data, and cannot, therefore, estimate HM accurately, we pursue a second-best 'bounds' approach. This uses the data that we observe to place plausible upper and lower bounds on HM, and thus HS. As always with a bounds approach, the hope is that this will narrow down the set of plausible outcomes in a meaningful way. In the case of the UK, we currently have access to data for HP and m (from M, X and P), and we also have information on the geographical dispersion of imports across their countries of origin (which allows us to recover HGD).

Setting the Bounds

Lower Bound

The case where HM is at a minimum (0) is where all importers have trivially small market shares: $\mathrm{HM}_\omega \approx 0 \; \forall \; \omega$ and (5) reduces to:

$$\underline{\mathrm{HS}} = (1-\mathrm{m})^2 \; \mathrm{HP} \tag{1.6}$$

This is equivalent to the standard practice in early SCP studies, discussed earlier, where, in effect, the concentration ratio was deflated by adding the magnitude of imports to the denominator but leaving the numerator unchanged. Loosely, this might be referred to as equivalent to a 'competitive fringe' importer assumption, but because of possible ambiguous interpretation[14], we prefer the term 'fragmented importers'.

Upper Bound

At the other end of the spectrum is the case of only a single importer from each source country, $\text{HM}_\omega = 1 \ \forall \ \omega$ and therefore:

$$\overline{\text{HS}} = (1 - \text{m})^2 \ \text{HP} + \text{m}^2 \ \text{HGD}. \tag{1.7}$$

We refer to this as 'country monopolies', and this represents the most concentrated outcome making a second working assumption:

A2 - No multinational sourcing. No importing firm imports from more than one source country or produces in the destination country.

Cases are clearly conceivable which would violate this assumption: for example, a large multinational car manufacturer, supplementing its production in the domestic country with imports from one or more foreign countries. However, this would not be violated by a vertically integrated multinational that sources intermediates from abroad for a finished product produced and sold at home.

In effect, this is a refined, disaggregated, version of the assumption, employed by Autor et al. 2020 as described earlier, who only segment the world into six broad regions and assume only one importer from each region.

These two assumptions set the bounds, but we also add an intermediate case which, speculatively, might indicate where within the bounds the reality might lie.

Intermediate Case

Imports from each source country are equally concentrated as are domestic suppliers. In which case, $\text{HM}_\omega = \text{HP} \ \forall \ \omega$ and therefore :

$$\text{HS}^{Int} = (1 - \text{m})^2 \ \text{HP} + \text{m}^2 \ \text{HGD HP}. \tag{1.8}$$

[14]It might refer to the case where imports enter at the world market price (especially perhaps for basic commodities) which either removes or limits domestic market power or alternatively to importers who are Stackelberg followers of the domestic leaders.

Returning to Proposition **??**(i), these cases now provide a more tangible feel to the word 'considerable'. First, Equation 1.6 confirms the intuitively obvious: with perfectly fragmented importers, the concentration of sellers is always less than domestic producer concentration since HS $<$ HP if m $>$ 0. Perhaps less immediately obvious, Equation 1.8 shows that this is also true in the intermediate case: the concentration of sellers is always less than producer concentration, even if the concentration of importers in each source country is identical to that of domestic producers.

HP$-$HS = HP (2m$-$m^2 (1+HGD)) $>$ 0 since 2 $>$ m (1+HGD) given m $<$ 1 and HGD $\leq$ 1.

On the other hand, from Equation 1.7 the upper bound on seller concentration may exceed the producer concentration if $(1 - \mathrm{m})^2$ HP + m^2 HGD $>$ HP, i.e.,

$$\frac{\mathrm{HGD}}{\mathrm{HP}} > \frac{2 - \mathrm{m}}{\mathrm{m}}. \tag{1.9}$$

This condition is more likely to hold the greater is import penetration (m) and the more geographically specialised are imports (the larger is HGD.) Below, we provide an assessment using data of how frequently this occurs, and for which industries.

1.5 Data

In order to assess HM accurately, we would need a source of trade data which includes information on individual importers, classified in such a way that it can be harmonised with the domestic production data at the four-digit SIC level from the BSD. Unfortunately, in the UK (and indeed most countries), official data on international trade by commodity are not harmonised with data on domestic production, such as censuses or business registers at the four-digit level, and nor are they readily available for individual importers.

1.5.1 Harmonising trade and production data

The best publicly available UK data at a suitable level of disaggregation is at the commodity level for what amounts to broadly the industries in the manufacturing sector[15] (UK HMRC Trade Statistics unit, HMRC 2018). This dataset furnishes comprehensive import and export data for several industries classified under the Standard International Trade Classification (SITC), fourth revision (Rev.4), offering detailed insights up to the five-digit level of disaggregation.

[15]HM Revenue & Customs, 'Overseas trade data table - UK Trade Info', www.uktradeinfo.com

Table 1.2: Matched Sample Coverage in 2018.

	Exports	**Imports**
Manufacturing share of UK total	44.60%	57.28%
Sample as a share of UK manufacturing	42.12%	50.45%
	Sample	Population*
Number of four-digit manufacturing industries	119	361

* Note: In fact, there are 614 four-digit industries in the current UK SIC system. We make various exclusions: industries for which there is very little data (typically very small industries with little or no UK production); or non-market, publicly owned, financial (for which 'turnover' cannot be defined in a comparable way to all other sectors) and wholesale fuel. We also exclude 142 for which there were major revisions in the SIC definitions in this period. (See Stephen Davies 2021 Table A1.)

For further information on the SITC system, refer to the United Nations publication from 2008 ('U.N., 2008'). The source currently covers 1996-2020, with information broken down by commodity and place of origin/destination. Domestic concentration data was collected from the UK Business Statistics Database, BSD (see section 2). In the event, we were able to match industry and commodity definitions for a panel of 119 of the four-digit industries in the BSD described earlier (Table 1.2). This sample includes half of all UK manufacturing imports and 42% of manufacturing exports. In turn, the manufacturing sector accounts for 57% of all UK imports and 45% of all UK exports. Thus, it is by no means comprehensive but it was the best concordance we could achieve with the summary data available.

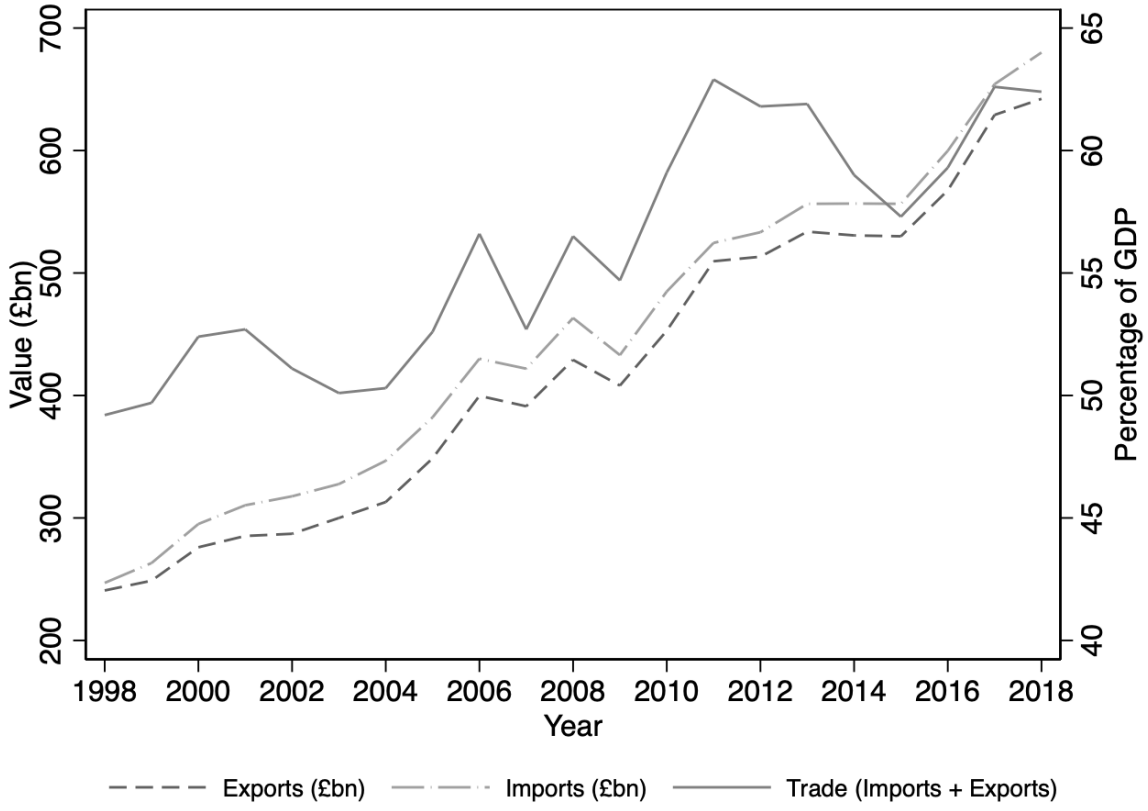
More positively, because the import data are disaggregated by country of origin, this enables us to estimate HGD and therefore the three special cases set out in the previous section.

1.6 Results

1.6.1 UK Trade 1998-2018

As a preliminary to making the trade adjustments, Figure 1.1 shows the growth of exports and imports over the period, along with their sum expressed relative to UK GDP. This confirms that exports and imports have grown steadily and largely in tandem over this period. Crucially, for present purposes, they have outgrown GDP, allowing us to apply Proposition **??**(ii) that levels of typical producer concentration have tended to become increasingly less reliable predictors of typical seller concentration during this period. Foreign firms have an increased share in total

Figure 1.1: Aggregate UK Exports and Imports 1998-2018



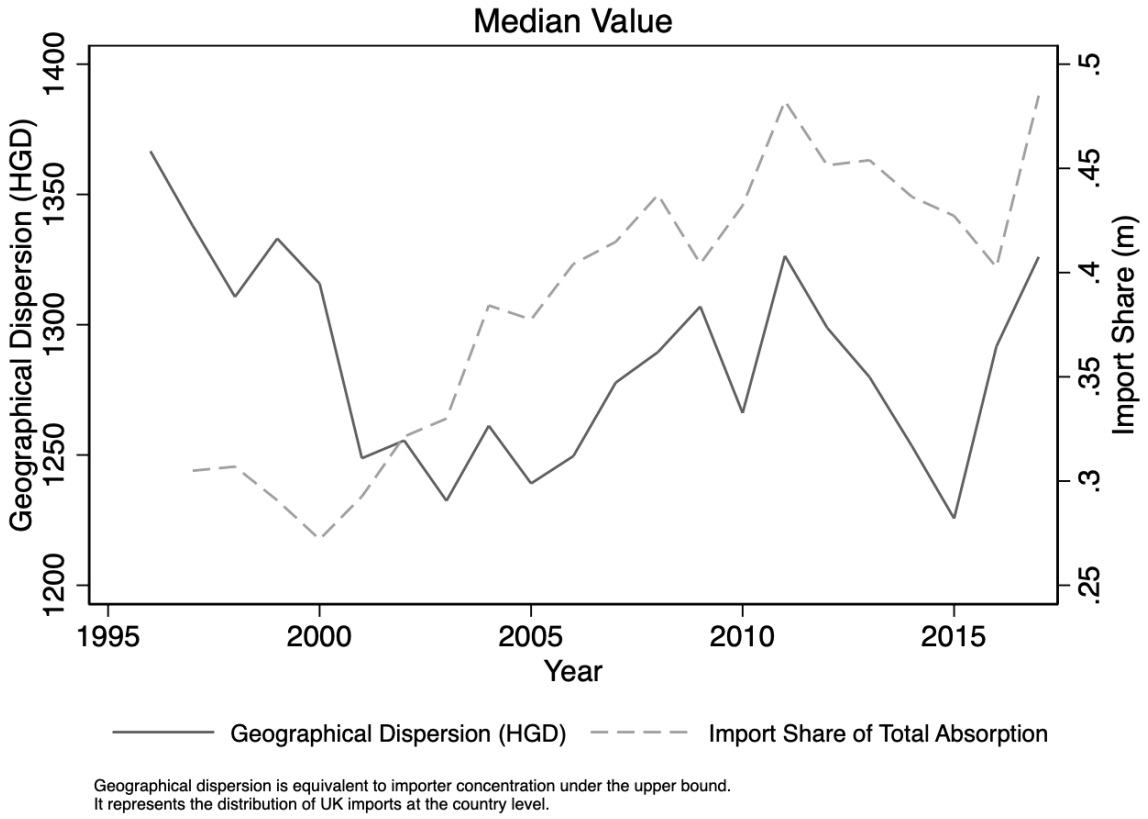
market sales and more domestic production is exported, two factors which are incorporated in seller concentration but not producer concentration.

Figure 1.2 shows how the sample average (median) import weight (m) and index of geographical dispersion (HGD) has moved over this period for the 119 industries. The import share confirms the continued persistent growth already shown in the macro data of Figure 1.1. Geographical dispersion has fluctuated, with no obvious trend, but always within a range of $1370 > \text{HGD} > 1150$, or more intuitively, between the equivalent of seven to eight equal-sized countries of origin.

1.6.2 The time path of typical seller concentration over time, 1998-2018

Figure 1.3 shows the time path estimates of the upper and lower bounds for a typical seller concentration (i.e. trade-adjusted concentration) relative to a typical producer concentration. For comparability, both are medians for the 119 matched sample of industries. This means that the time series here for producer concentration is not the same as that in Stephen Davies 2021, which shows the median for the much fuller sample of 361 industries. Both follow the same

Figure 1.2: Import Share and Geographical Dispersion



broad pattern over the period, the smaller sample here records noticeably higher magnitudes. This reflects the fact that manufacturing industries for which we have trade data tend to be more concentrated than those in other sectors [16]. Turning to the bounds and the intermediate curve in the figure, there are four striking features:

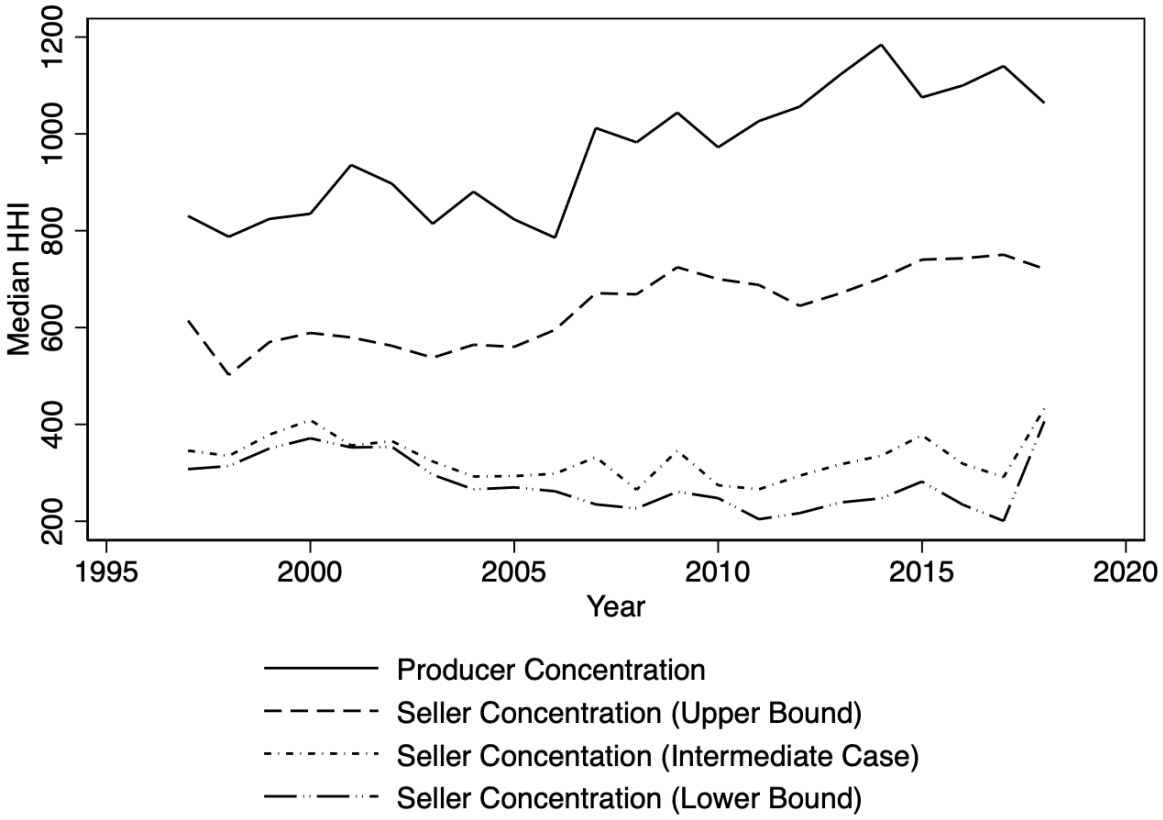
1. Even the upper bound is consistently and notably lower than the UK producer concentration. Thus, we can now conclude that, typically, trade-adjusted seller concentration is much lower than UK producer concentration even making the most concentrated of assumptions about importers[17]

2. At the lower bound, there was a negative downward trend over the period. This confirms that, of course, the 'fragmented importer' assumption will tautologically lower the

[16] An explanation for this result is beyond the scope of this paper but one could argue this is because these industries are open to international trade and therefore face tougher competition leaving a smaller number of more efficient firms.

[17] Strictly speaking, there is a special circumstance where importers might be even more concentrated: where large multinationals are the sole importers from more than one foreign country. While multisourcing of imports into the UK, may sometimes occur, it is unlikely that the multinational will have such widespread monopoly power. At this stage, we rule out this possibility. However, we note that it warrants future empirical validation.

Figure 1.3: Evolution of Producer v. Seller Concentration



estimated concentration, but, more interestingly, it would be sufficient to overturn the previous upward trend detected in producer concentration over the period.

3. The intermediate curve clearly lies much closer to the lower than the upper bound, i.e., if the importers from each country selling to the UK were equally concentrated as UK producers, the concentration of all sellers in UK markets would be less than half as concentrated as UK producers. However, there is no discernible trend in the intermediate series.

4. The dispersion between lower and upper bounds appears to have widened over the period – the state of our ignorance is, if anything, increasing, which underlines the need for improved, i.e. firm-level, data for the UK.

1.6.3 Incidence of high concentration markets

One of the most striking features in the series for producer concentration (HP) in Figure 1.3 is that its median exceeds 1000: more than half of the matched sample of four-digit manufac-

Table 1.3: Distribution of Concentration Levels in Sample

	Producer (HP)	**Seller (HS)**		
HHI Range		**Upper Bound**	**Intermediate**	**Lower Bound**
0 - 1000	54	76	95	98
1001 - 1500	21	24	11	9
1501 - 2000	13	8	5	5
2001 - 2500	8	7	6	5
$>$ 2500	23	4	2	2
Total	**119**	**119**	**119**	**119**

Figures are for 2018. A reminder: the 'Upper', 'Intermediate' and 'Lower' bounds refer to the alternative assumptions on importer concentration.

turing industries is 'concentrated' using a standard benchmark statistic. Bearing in mind that concentration in the typical four-digit industry is likely to be much lower than in its constituent anti-trust markets, this points to a manufacturing sector in which high producer concentration is pervasive. This is confirmed in Table 1.3, which shows that 65 of the 119 industries (55%) are concentrated [18].

However, once the trade adjustments are made, less than 20% of industries remain in the concentrated range at the lower bound, and even at the upper bound, 43 industries (little more than a third) are concentrated.

Again, it is necessary to remember that even unconcentrated four-digit industries may include concentrated anti-trust markets, and it is also apparent that there is a small core of industries which will remain concentrated regardless of whatever assumptions are made about the concentration of importers: even at the lower bound there are 12 such industries, rising to 19 at the upper bound. Indeed, these include a smaller subset of industries in which the upper bound trade adjustment actually increases the level of concentration. These are shown by the points above the 45-degree line in Figure 1.4.

To illustrate, two examples are shown in Table 1.4. In both, imports render (upper bound) seller concentration higher than producer concentration. In the case of watches, this makes an already highly concentrated industry even more highly concentrated; in the case of imitation jewellery, this shifts it from unconcentrated to concentrated.

[18] It should be recalled that the incidence of highly concentrated industries here (for a sample of manufacturing industries) is much higher than that for the wider and larger sample shown earlier in Figure 1.1 and Table 1.2

Figure 1.4: Industry Level Producer v. Seller Concentration (Upper Bound)

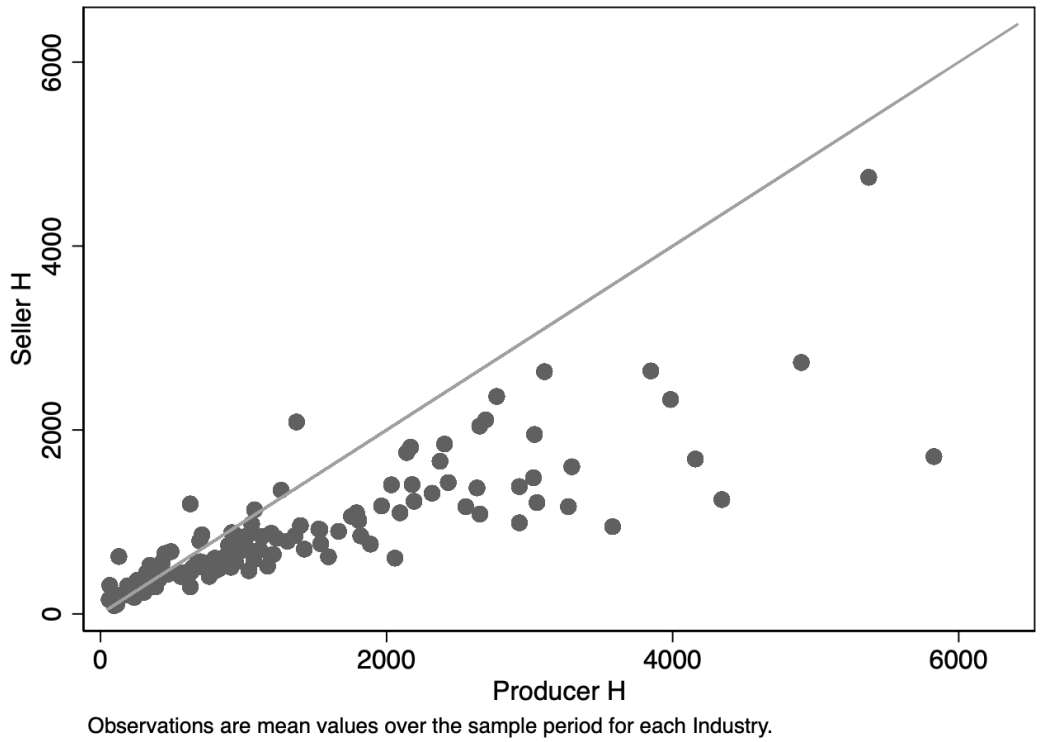


Table 1.4: Industries where Seller concentration may exceed Producer Concentration

	Seller HHI	**Producer HHI**	**Import Share**
	HS	HP	m
Manufacture of watches and clocks	2087	1371	90%
Manufacture of imitation jewellery and related articles	1196	628	75%

Average level of concentration in the period 1998 - 2018.

1.7 Conclusions & qualifications

To our knowledge, this paper is the first attempt to adjust the current evidence on concentration in UK industries, for the effects of international trade – effectively, converting measures of producer concentration into indices of seller concentration. Such a conversion is desirable if we are interested in the nature of competition in UK markets.

This task has been considerably constrained by the absence of publicly accessible data on imports and exports at the firm level and of a ready-to-use concordance between UK data on domestic business activity and trade commodity classifications. For these reasons, we are unable to make exact, and instead, we opt for a bounds approach, corresponding to alternative extreme assumptions about the (unknown) concentration of importing firms.

While these bounds are significantly and increasingly different over time, they do allow us to draw some important qualitative conclusions. In particular, even at the upper bound, typical seller concentration is lower than producer concentration. This means that the number of four-digit industries which would be classified as 'concentrated' or 'highly concentrated' is much reduced. It also seems likely that the upward trend observed in producer concentration in the first two decades of this century is, at most, much less pronounced and, at least, not at all paralleled by seller concentration. These are important qualifications to the prevailing consensus from most previous UK studies.

Having said this, the inevitable imprecision of our results is not ideal; nor is the fact that we have only been able to match business and trade data for a subset of manufacturing industries. It is to be hoped that those responsible for collecting and producing the relevant statistics can be persuaded to allow better access in the future.

It is also important for us to stress two important limitations on the interpretation of our results. First, the four-digit level of industry aggregation we are obliged to use is far too aggregate for us to claim with confidence that these industries correspond to any meaningful definition of an anti-trust market (ATM) level (the level at which competition takes place.) In the UK's industrial classification, the little more than 600 four-digit industries undoubtedly comprise a far greater number of ATMs (our wild guess would be in excess of 10,000). This is important because recorded concentration tends to increase the less aggregated is the industry definition. For example, concentration in the pharmaceutical industry broadly defined is relatively low but this conceals the fact that it may be extremely high, with few significant sellers, in many of the

therapeutic classes which make up pharmaceuticals.

Second, we have stressed throughout the paper that concentration should not be interpreted as a clearcut measure of competition. Concentration may be an (admittedly interesting) outcome of the competitive process, but not necessarily a determinant of market power – especially when outcomes are only observed in snapshots. Further research is needed if more meaningful measures of the dynamic competition can replace simple comparisons over time of concentration. These more conceptual doubts will be a major focus of our future research.

The purpose of this paper, above all else, is to stress the need to fully incorporate foreign firms and foreign sales into any IO-related analysis. Our concept and decomposition of seller concentration represent one approach towards this goal of combining importer concentration with domestic producer concentration. We then adopt a bounds approach which can be used even in the absence of perfect data, to better understand the role of foreign competition in determining concentration.

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Appendix A

Derivation of HS

The HHI of an industry containing two types of firms can be expressed in terms of the HHI among the two groups and the share of each group in the overall industry. In other words it is possible to combine two HHI measures to generate an overall HHI. Our measure of HS detailed above is an example of this where the two groups are domestic sales and imports.

Suppose we have two firm types, domestic producers, *d*, and foreign importers, *f*. Let s_d^{DS} be the share of a domestic producer d in total domestic sales (T-X). Similarly let s_f^M be the share of an importing firm f in total imports, M. By construction therefore $s_f^{DS} = s_d^M = 0$. Domestic producers have no share in imports and foreign importers have no share in domestic production. From this we can generate HDS, the HHI of domestic sellers and HM, the HHI importers in the usual fashion.

$$HDS = \sum_{d=1}^{D} \left(s_d^{DS}\right)^2 \quad \text{where } d = 1, ..., D. \tag{10}$$

$$HM = \sum_{f=1}^{F} \left(s_f^{M}\right)^2 \quad \text{where } f = 1, ..., F. \tag{11}$$

To clarify, an HM value of 2500 would mean we have 4 equally sized importers in this market (or some equivalent level of concentration). Total sales in the market, T, are the sum of imports and total domestic production excluding exports, i.e., $T = (P + M - X)$. With import share (sometimes called import penetration) equal to the share of imports in total sales, $m = (M/T)$ We can now define each firm's share of total market sales, s_f^T for importers and s_d^T for domestic producers. For each foreign importer, we can multiply their share of total imports by the share of imports within total sales to get the share of an individual importers. Formally, $s_f^T = m \cdot s_f^M$. In words, if an importer had 25% of total imports and imports cover 20% of total market sales then that importer has a 5% share in total sales. This logic can be applied to domestic producers as well whose share in total sales is the inverse of of import penetration. Formally, $s_d^T = (1 - m) \cdot s_d^{DS}$. Even if s_d^{DS} and s_f^M are unknown, because the one weight is applied equally to all domestic firms and another for all importers, we can factor these weights out of the HHI calculation as follows:

$$\text{HS} = \sum(s^T)^2 = \sum(s_d^T)^2 + \sum(s_f^T)^2$$

$$\text{HS} = \sum((1-m)s_d^{DS})^2 + \sum((m)s_f^M)^2$$

$$\text{HS} = (1-m)^2 \cdot \sum(s_d^{DS})^2 + m^2 \cdot \sum(s_f^M)^2$$

$$\text{HS} = (1-m)^2 \cdot HDS + m^2 \cdot HM$$

Where m is import share, HM is the HHI among importers only, and HDS is the HHI of domestic producers exclusive of exports. The value of HS can be interpreted in the same way as a standard HHI value, but it now covers the domestic market sales of both domestic and foreign firms.

Chapter 2

An analysis of Seller Concentration in UK Markets

Abstract: This chapter examines the impact of foreign firms and imports on market concentration in UK industries, arguing that conventional methods often underestimate concentration levels by ignoring foreign entities. Using a novel dataset spanning 230 UK industries from 2008-2019, we develop metrics that include imports while excluding exports, providing firm level "seller concentration" measure that more accurately reflects the competitive landscape faced by UK consumers. We present a number of stylised facts surrounding on how the *seller concentration* can change our understanding of the competitive landscape. Our findings reveal that when modelling sellers, concentration can be much higher than previously thought and the identity of those we would consider the largest firms can change dramatically. The presence of large foreign firms often drives concentration, with foreign importers frequently ranking among the largest players in the market. Our analysis highlights that traditional producer-focused concentration metrics may mischaracterise market structures, overlooking markets with high foreign influence and potentially uncompetitive conditions. The paper emphasizes the importance of incorporating international trade data in market analysis to guide more effective competition policy.

Keywords: Producer Concentration, Seller Concentration, Competition, HHI.
JEL classifiers: International Trade, Industrial Organisation.

2.1 Introduction

In the past decade, serious concerns over increasing market power have emerged, spurred by a wave of influential studies that point to rising markups (De Loecker, Eeckhout, and Unger 2020a), weakening regulation (Philippon 2019), and the rise of 'superstar firms' (Autor et al. 2020). Even one of our most fundamental indicators of market power, industrial concentration, appears to be on the rise, (OECD 2018, Furman and Orszag 2018, CMA 2022). These concerns however do not exist without dispute and a plethora of studies refuting these claims.

One such counter argument relates to the role of foreign firms and how many analyses often omit these key actors. While by no means a new concern, Carr and S. Davies 2022 document how various methods have been used to attempt to model foreign competition in the absence of suitable data on foreign firms, with the prevailing wisdom being that foreign imports into a domestic market will have a pro-competitive effect. Evidence for this view can be found in the work of Amiti and Heise 2021 who were one of the first to estimate concentration on the universe of firms operating in a number of US market, i.e. including foreign importers. But the question of whether this result holds for other economies remains open, especially given the size of the US economy and its largest firms. Markets are more internationally integrated than they have ever been, and while some signs of decoupling are starting to show, foreign firms still play a significant role in many economies, thus a deeper understanding of not just the patterns of trade but how this can influence competition is needed.

The aim of this paper is to first demonstrate that an appropriate handling of international trade, i.e. controlling for foreign firms and imports while excluding exports, can increase the measured level of concentration in domestic markets, and that by not doing so many markets may be inappropriately characterised using traditional concentration benchmarks. This can bring unnecessary attention from competition authorities to markets that are not concentrated, while highly concentrated markets are overlooked because foreign firms are not being studied. The second aim is to show that outside of import penetration, foreign firms in and of themselves have a significant presence and are often the cause of high levels of concentration. Of course concentration is not the same competition, but the levels of concentration we find when accounting for trade would be of concern to any anti-trust authority. It is therefore a necessity that we correctly measure the presence of foreign firms to understand how foreign and domestic firms coexist and interact within a domestic market. Not doing so will generate bias in the

development and implementation of anti-trust policy by over looking these foreign giants, and mean we potentially overlook uncompetitive behaviour and abuses of dominance because we are not studying the largest sellers in a market.

We analyse a panel of 230 four-digit UK industries between 2008-2019, presenting a novel dataset that covers the universe of firms operating in these UK markets, and find that concentration is much higher than expected when we incorporate foreign firms. We use data from the UK's Secure Research Service to match imports and exports to firm turnover data and highlight the difference between *Seller Concentration* and *Producer Concentration*. To our knowledge this is the first time seller concentration has been measured using data on the universe of firms for the UK. Our paper in that respect is most similar to Amiti and Heise 2021 who find that once importers are accounted for, the level of concentration seen in US markets is lower than previously thought, a large number of small foreign firms having eroded the market share of the largest domestic competitors. We find that for the UK the opposite is true, when we account for imports, market concentration is significantly higher than previously thought. We also find some evidence that foreign firms have a distinct impact on market concentration outside of the impact of import penetration alone. These results suggest the de-concentrating effect of trade that is typically assumed by academics and policymakers, does not hold for a number of UK markets. For policy makers, understanding the prevalence of foreign firms in UK markets is essential to any analysis of competition. The fact that foreign imports can increase concentration in some markets, means they are large players and overlooking these firms is overlooking those firms with potentially significant market power. Throughout the paper we present a number of stylised facts to show the way in which our understanding of market concentration can change when we account for international trade correctly.

The rest of the paper is structured as follows: Section 2.2 discusses previous attempts in the literature to model concentration from foreign firms. Section 2.3 details the dataset used and our methodology. Section 2.4 highlights trends in our measures of concentration and the increase seen when accounting for foreign firms. Section 2.5 models the determinants of seller concentration and the impact of both import penetration and the presence of foreign firms before section 2.6 concludes.

2.2 Empirical work on seller concentration

As discussed by Carr and S. Davies 2022, the seller concentration faced by consumers in a market can be broken down into the concentration of domestic and foreign firms. The level of seller concentration is therefore influenced by the concentration among importers and the share of imports in total sales, when these are significant, seller concentration will be significantly different from producer concentration. This paper is related to the literature on market concentration in the context of international trade, specifically focusing on the concentration of imports. It builds on recent efforts to incorporate measures of seller concentration, with Amiti and Heise 2021 providing a prominent example for the U.S. market. We contribute to the literature in two ways; we first show that foreign firms can increase market concentration in smaller developed economies like the UK and second we show that the role of foreign firms is distinct from the role of import penetration.

International trade is dominated by a relatively small number of large firms (Bernard, Jensen, et al. 2018, Castellani, Serti, and Tomasi 2010, Mayer and Ottaviano 2007, and WTO 2008). Bernard, Jensen, et al. 2018, p. 607 detail how these largest firms are not only more productive but are substantially integrated internationally in the sense that they export more of each product to each market, export more products to each market, export to more markets, import more of each product from each source country, import more products from each source country, and import from more source countries. Freund and Pierola 2015 show that the very largest firms in an country shape export patterns. Among a sample of 32 countries they find the top firm on average accounts for 14 percent of a country's total (non-oil) exports, and the top five firms account for 30 percent.

Changes in import penetration can be decomposed into an extensive and intensive margin. The extensive margin refers to the introduction or removal of new products, and the entry / exit of importers, while the intensive margin refers to any growth or reduction among existing products from established importers. Bernard, Jensen, et al. 2009 provide some evidence that, for the US at least, the intensive margin is the stronger determinant of changes in import penetration. By contrast, Bernard, Redding, and Schott 2011 find the extensive margin is negatively affected by the physical distance between source and destination, while positively related to market size, but find no evidence the intensive margin is affected.

The work of Feenstra and Weinstein 2017 provides a rough estimate of seller concentration

for the US. They analyse imports at the country level using import HHI's for each source country. These import HHIs are they weighted by that country's share of the US market. In other words, for each country trading to the US they have data on the concentration of imports from that country, e.g. the HHI among Chinese exporters to the US. These HHI are then aggregated, by weighting each country's share of total absorption in the US, e.g. % of total US sales that are from China. Their results suggest US seller concentration fell between 1992 and 2005.

Amiti and Heise 2021 are the first to provide estimates of seller concentration using firm-level data, and find that the correction for imports on average decreased the HHI level across US five-digit industries by roughly 25 percent from around 650 to around 500. Industries with high import penetration saw increased concentration amongst the domestic competitors, and higher import penetration reduced the combined share of the largest domestic firms, but because importers entered at the lower end of the sales distribution, seller concentration fell. Bonfiglioli, Crinò, and Gancia 2021 find that import penetration from sea shipments in US two-digit manufacturing industries has risen to around 28 percent in recent decades. However, despite this growth, the concentration among importers has declined over the same period.

The question of whether these trends found in the US, will hold for other countries is still open. There is evidence that the competitive landscape within Europe does not follow a similar pattern to the US (e.g. Philippon 2019) but questions regarding potentially weakening competition persist (e.g. Koltay, Lorincz, and Valletti 2023). Indeed, two preliminary findings suggest that seller concentration in Europe may have moved in a manner that is much more concerning. Kalemli-Ozcan et al. 2015 find that in Europe, increased market concentration may be driven by foreign owned firms, while Bajgar, Berlingieri, et al. 2023 find that adjusting for trade in Europe, the mean eight-firm concentration ratio was higher than baseline, the complete reverse of the situation both they and Amiti and Heise 2021 find for the US.

2.3 Data

Data on firm ownership, industrial classification, employment and turnover is provided by the UK Business Structure Database (BSD). The BSD is a yearly extract of the Inter-Departmental Business Register (IDBR) created to provide a panel on UK firms over time. It covers any firm registered for VAT or PAYE purposes, covering 87 percent of UK employees and the associated economic activity (Lemma et al. 2023).[1]

[1]For more information on the BSD see the Integrated Data Service here.

The second source of data is the Trade in Goods (TiG) database which provides the value of firm level imports and exports by country of origin / destination and commodity code. The TiG is calculated from the HMRC's Overseas Trade Statistics (OTS) publications, which they collect for administration and tax purposes, and adjusted by the Office of National Statistics (ONS) to suit researchers and help integration with other ONS datasets.[2] Analysis by Wales et al. 2018 shows the extent to which the resulting TiG dataset covers the near entirety of UK international trade and closely aligns with the HMRC's own publications.[3]

We also supplement with data from the UK's Annual Buisness Survey which we use to generate measures of R&D participation, advertising and capital expenditure at the industry level [4].

Each datasets classify firm activity into industries via the UK Standard Industrial Classification system 2007 (SIC), with the highest level of disaggregation being 5-digit codes e.g. 28922 - Manufacture of earth moving equipment. [5] The TiG data also classifies imports and exports to the commodity level using the U.N.'s Harmonised System.[6] One important distinction is the TiG data is given at the reporting unit level, while the BSD information is provided at the enterprise level. A reporting unit (RU) represents business activity that exists at a specific location meanwhile an enterprise is defined as the smallest combination of units that benefit from a degree of autonomy. The RU is the more disaggregated measure and an enterprise can contain multiple reporting RUs. The term 'simple' enterprise is used to refer to those enterprises that contain a single reporting unit, meanwhile 'complex' enterprises are those that contain multiple reporting units, e.g. a chain of restaurants all operating under the same name. For most firms, the reporting unit and the enterprise are one and the same (ONS 2024). The larger structure of enterprise group, covers the largest and most complex firms wherein multiple enterprises (each of which can contain multiple RUs) are bound together by legal and/or financial links.

In both the BSD and TiG each firm is allocated a primary and secondary SIC code based on its main business practice and any additional market in which it has a significant presence. The hierarchical structure of RUs, enterprises and enterprise groups allows us to compartmentalise the activities of larger firms into specific industries. E.g. An enterprise's main focus may be

[2]Details on the OTS are provided by the HMRC here and Wales et al. 2018 for more detail on TiG.

[3]These two datasets were accessed through the UK Office of National Statistics' Secure Research Service and are therefore confidential. This has limited our ability to disclose information on specific industries, in order to prevent identification.

[4]More information on the ABS is available from the ONS here

[5]A full breakdown of the structure of the SIC can is provided by the ONS and can be found here

[6]More specifically HS07, details here.

within SIC 1041, manufacture of oils and fats, but it may contain a RU within SIC 1042, manufacture of margarine. Analysis of the RU in 1042 then allows us to understand the firms activity within that industry alone.

Enterprise turnover is reported in the BSD but this excludes imports and exports (see Appendix .1). The BSD, as an extract of the IDBR, calculates turnover based off PAYE and VAT returns (ONS 2016) with some additions for the largest firms from the UK's Annual Business Survey (ABS). Imports and exports are not necessarily subject to the same VAT requirements as home sales (see HMRC 2018 and HMRC 2023) which can help explain some of the omission. During our sample period, 2008-2019, imports and exports in the TiG data were collected from two sources: all non-EU trade is measured from the customs declarations required by firms to process the movement of goods at the border, while all EU trade was monitored through Intrastat. The Intrastat system is used by members of the European Union for trade with other EU member states. It is a monthly survey with responses required by all importers and exporters above a certain size with adjustments made to estimate trade below this threshold (see HMRC 2024 for more information). To accurately measure firm sales and production using these two dataset we therefore need a way to match the data together and seperate out any imported intermediates that are used as inputs.

2.3.1 Merging Datasets: Concordance Procedure

In order to combine the TIG and BSD data, a means of matching HS codes to SICs is required. We achieve this through a three-stage matching procedure. In the first stage, a walk through of HS to SIC is achieved through the use of published correspondence tables given by U.N. 2024. However, a large number of unmatched codes remain. In the second stage, unmatched HS codes are matched to SIC codes based on their six- and four-digit labels respectively, with matches assigned based on text analysis of the two labels. In the final stage, the remaining unmatched six-digit HS labels are assigned an SIC via text analysis on the full UK SIC sub-industry breakdown. More details on the text analysis and use of U.N. guides can be found in Appendix .2. For almost all HS codes this procedure yields at least one SIC code match.

Firms import and export a range of different goods and so the purpose of this concordance procedure is to separate imports of intermediate inputs from those that align with a firm's main activity. Imports are included within a firm's total sales if the matched SIC of the goods imported aligns with the firm's assigned primary SIC. All others are considered intermediate

inputs and are not included in the analysis below. As noted by Miroudot, Lanz, and Ragoussis 2009 trade is dominated by intermediates, and we find this in our concordance as well. While there is significant heterogeneity among firms in importing and exporting, which we will examine later, we find on average firms import nearly twice as much in terms of intermediates than in final goods.

Our final sample covers 390,000 firms across 230 five-digit industries which account for around 16 percent of total UK turnover in 2019. Our concordance procedure gives us exports worth 25 percent of total UK goods exports and final imports, worth 23 percent of total UK goods imports.

Box 1 - Groupings for concentration measures

Types of output

- P Domestic Production
- X Exports
- M Imports
- T Total Sales = (P + M - X)

For a given firm i shares are then calculated as follows

- s_i^{home} $(P_i - X_i)/(P - X)$
- $s_i^{producer}$ P_i/P
- s_i^{seller} T_i/T

Therefore

- $CR5_{home} = \max_{\text{top 5}} \sum_{i=1}^{n} s_i^{home}$ $HHI_{home} = \sum_{i=1}^{n} (s_i^{home})^2$
- $CR5_{producer} = \max_{\text{top 5}} \sum_{i=1}^{n} s_i^{producer}$ $HHI_{producer} = \sum_{i=1}^{n} (s_i^{producer})^2$
- $CR5_{seller} = \max_{\text{top 5}} \sum_{i=1}^{n} s_i^{seller}$ $HHI_{seller} = \sum_{i=1}^{n} (s_i^{seller})^2$

2.3.2 Defining the Relevant Market

The terms industry and market are often used interchangeably but for our purposes a clear distinction is required. In our work, we define an industry for a specific good as the collection of firms producing that good within a particular country (e.g., the UK car industry). Meanwhile, the market for a good refers to the firms engaged in selling that good within a specific country (e.g., the UK car market). To study the difference between the two we must be able to measure imports, exports and 'home' sales at the firm level. The BSD data provides turnover figures at the enterprise level, assigned to a primary SIC, but as mentioned above, omits imports and exports. Firm-level import and export data is provided in the TiG dataset for RUs which we aggregate to the enterprise level and match to the BSD turnover figures. In chapter 1 we distinguish between three groups of economic activity, and Box 1 provides clarification on the exact nature of these measures. The first group, referred as the *baseline* or home group, includes domestic sales by domestic firms. Their market shares are calculated based on this portion of their output that is produced and sold in the UK, resulting in what we define as Home Concentration. The second group is the *production* group wherein we look at domestic firm output as a whole and thus exports are included. Market shares are then calculated by the firms total production relative to total production in that industry, regardless of the destination of whether those goods are sold in the UK or overseas. This gives us our measure of *Producer Concentration*. Finally, there is the *sales* group, which covers sales by both foreign and domestic firms in the UK market. This covers the sales of goods by domestic and foreign firms, whether they were produced in the UK or imported from overseas, (not including any imported intermediates). A firm's market share is now its share of total sales within the UK with both the domestic and foreign firms having a stake in the market. This grouping provides our measure of *Seller Concentration*.

Domestic and Foreign Firms

We draw a distinction between foreign and domestic firms based on two variables, the location of their parent companies and their level of import intensity. All enterprises that have immediate and ultimate ownership outside of the UK and import more than 50 percent of their total sales are classified as foreign firms. This is, admittedly, a somewhat arbitrary definition, and it could be argued that all firms with recorded turnover should be classified as domestic. However, we argue that any firm with a minimal share in home sales, but a significant market presence through imports, and that is controlled by foreign owners, should be classified as a foreign

importer. We use this definition in the analysis below. It is worth noting that this definition is more restrictive than the Foreign Direct Investment enterprise definition adopted by the IMF, which is used to define foreign firms in Kalemli-Ozcan et al. 2015.[7]

Distinguishing between foreign and domestic firms is crucial for a number of reasons. Firstly, in industries of strategic or political importance, policymakers should be concerned when a small number of foreign firms control a majority of the market. This is combined with wider debates around a return to protectionism globally (Khandelwal 2020), concerns about American influence over the British economy (Hanton 2024), tensions with China and their push into electric vehicles (The Economist 2024), dependence on Russia gas in the aftermath of the Ukraine invasion, and a lack of economic and productivity growth in the UK. In each, the power of foreign firms in domestic markets is a key issue. Where foreign firms dominate, regulators may implement policies to support domestic competition or protect smaller domestic players from being crowded out. Secondly foreign firms face different competitive pressures. They likely have different cost structures and handle different risks including tariffs, transportation costs, facing multiple competition authorities and regulations not faced by the domestic firm, exchange rate risk, and labour market conditions in their home country. International trade is dominated by a smaller number of large firms and thus foreign importers will likely have access to a number of markets and thus may have better market knowledge from sales in other countries and benefit from economies of scale, thus gaining a significant competitive advantage. Foreign firms may also have a better ability to weather challenging economic conditions in the domestic economy.

2.3.3 Measures of Concentration

We consider two static measures of market concentration, the concentration ratio (CR) and the Herfindahl-Hirschman Index (HHI). A concentration ratio shows the combined market share of the top X firms for a given point in time. For example a CR10 of 0.9 tells us the top 10 firms in a market produce/sell 90 percent of all the goods in that industry/market. CRs can be calculated at different levels of aggregation (e.g., CR5, CR20, and so on), and have the benefit of being easier to calculate and somewhat more intuitive than alternative measures. However, they do not cover all the firms in the market, and can hide important facts about the distribution of shares (e.g. among those top 10 firms, one firm may have a much larger share than all the other

[7]The IMF defines any firm whose equity is owned by foreigners in excess of 10 per cent as a Foreign Direct Investment enterprise. For details, see here.

nine firms). To counteract this, we also use the HHI, which is calculated as follows:

$$HHI = \sum_{i=1}^{n} (s_i)^2.$$

Where $i = 1, ..., n.$ represents the number of firms in a market, and s is their market share as a %.

The HHI can range from 0 to 10,000, representing perfect competition and monopoly respectively. In the UK, a market/industry with an HHI of more than 1,000 is considered to be concentrated, and those with HHIs of more than 2,000 highly concentrated (CMA 2020). We proceed with both measures of static concentration for convenience.

Box 1 provides some clarification on our different measures but in essence each concentration metric, HHI or CRX can be calculate for any of the three firm groupings. The first group concerns production activity within the UK (P), the second covers only domestic sales by domestic firms ($P - X$), and the third pertains to all domestic sales (T). The concentration metric is then calculated using the firm shares appropriate to the relevant group, e.g. the $CR5^{producer}$, $CR5^{home}$, and $CR5^{seller}$ use a firm's share of production, home sales and total sales respectively.

2.4 Descriptive Statistics

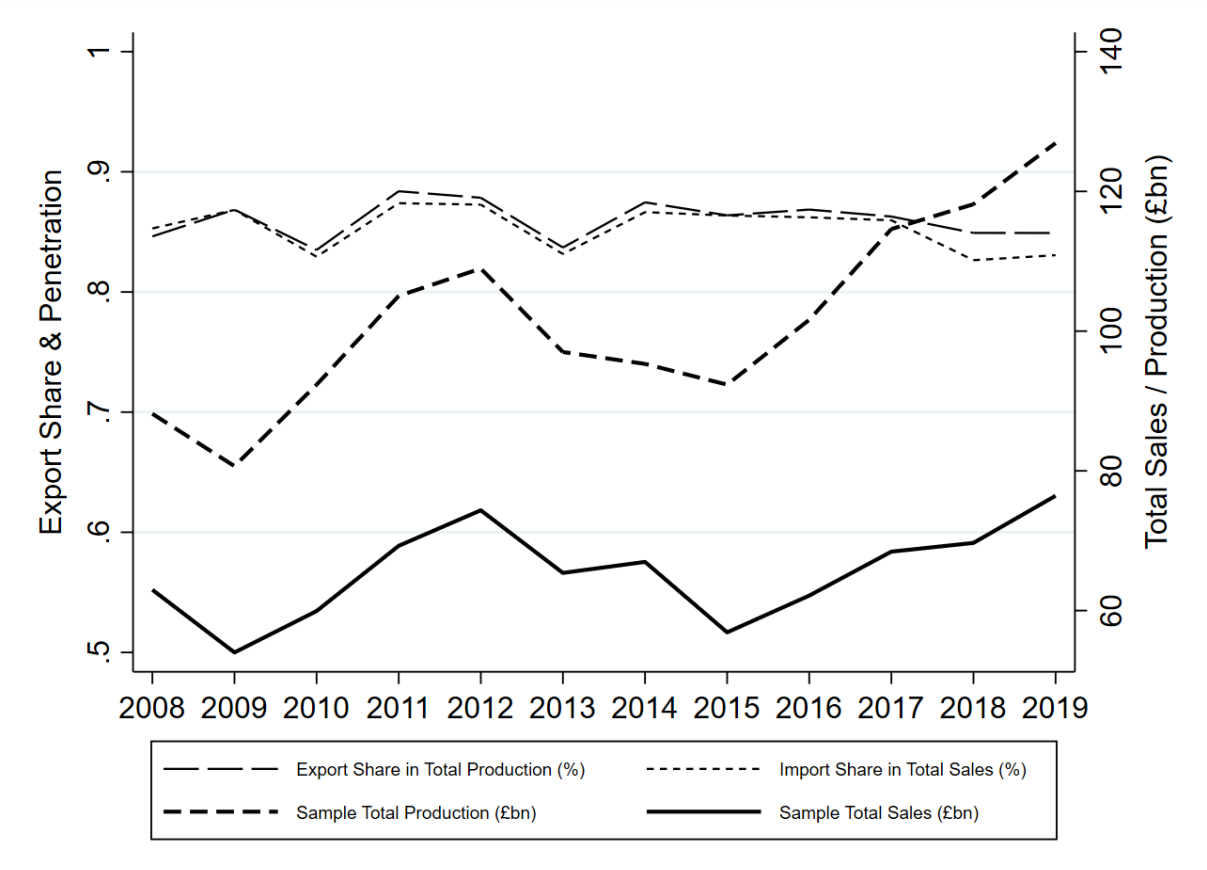
As can be seen from Table 2.1, participation in international trade is highly skewed, with the largest firms possessing the highest share of imports (exports) as a percentage of their total sales (production). We refer to this as firm level import (export) intensity, as opposed to the industry share of imports and exports (sometimes referred to as import/ export penetration). For all firms in the sample, on average only 3.4 percent of their total sales and 4.1 percent of their total production is imported/exported. However, when we consider the top 25 sellers/producers in each industry these averages rise to 63.4 percent and 68.3 percent. We can also see that larger industries tend to have a higher incidence of trade. Weighted by total absorption in the market (T) or industry (P) we see that the mean import and export intensity are much higher than the unweighted mean, rising to around over 50 percent. These results are not new, the dominance of large firms in international trade is well documented. The largest firms account for a disproportionate amount of international trade, and the largest importers and exporters are found in countries' largest industries (Bernard, Jensen, et al. 2007, Bernard, Jensen, et al. 2018, and Amiti, Itskhoki, and Konings 2014 Freund and Pierola 2015).

Table 2.1: Firm level trade intensity

	Import Intensity	Export Intensity
Unweighted Mean	3.4%	4.1%
Firm Weighted Mean	52.6%	51.3%
Top 25 Mean	63.4%	68.3%

Averages taken across all 230 industries and for the year 2019.

Figure 2.1: Total production, sales, mean export share & import penetration



Mean value of import penetration and export share across 230 four digit industries in sample and value of total sales (T) and total production (P) in sample between 2008 and 2019.

Figure 2.2: Concentration time series

(a) Mean Concentration

(b) Weighted by Total Absorption

Average concentration among 230 four digit industries between 2008 and 2019. Home HHI calculated on shares in domestic sales (P -X), Seller concentration shares are based on total sales (T), and Producer HHI is based on total domestic production (P). Weighted averages are based on the relevant absorption metric in each industry / market, i.e.Home HHI is weighted by P-X, T for Sellers and P for Producers.

Figure 2.1 shows us the mean share of imports and exports in total sales and total production at the industry level. Interestingly we see a very stable share of exports in total production and a very stable level of import penetration, both hovering around 85 percent in our sample. This is despite significant growth, with total sales in our sample rising from £54bn in 2009 to £76bn in 2019, and total production rising from £88bn to £126bn. It is worth noting the total production of all the industries in our sample is consistently about £40B higher than total sales, and the two move in a similar pattern. The UK's overall trade deficit is well-documented, but here we find exports in our sample exceed imports. Of course our sample is our a slice of the UK economy but it is also worth reminding the reader the figures presented here are final goods only, whereas the majority of imports consist of intermediate goods (Miroudot, Lanz, and Ragoussis 2009, Koopman et al. 2010 and R. C. Johnson and Noguera 2012.)

As mentioned above, the impact of imports and exports on concentration depends on both the level of concentration among importers and exporters but also on the import and export share of the market or industry. Figure 2.1 represents a highly aggregated view of the markets in our sample and hides significant heterogeneity which we investigate below but shows that imports (exports) as a whole have not seen any drastic increase as a share of total sales (production).

2.4.1 Aggregate Trends

Figure 2.2a shows the mean level of our HHI concentration measures across the sample for the years 2008 to 2019. The first thing to note is that both seller and producer concentration are much higher than the home or baseline measure. This is a result of both the prevalence of imports (exports) in these markets (industries) and the unequal distribution of that trade among firms, with importing and exporting activity being much more concentrated than home market sales alone. Second, the average level of producer and seller concentration is highly concentrated as defined by common anti-trust guidelines with producer concentration nearly exceeding 2500, and seller concentration nearly exceeding 2750 for the full duration. To put this into perspective, an HHI 2500 is equivalent to a symmetric 4 firm oligopoly. Third, we see that while home concentration has appeared to increase since 2009, both producer and seller concentration are relatively stable. Finally, we also see that seller concentration is higher than producer concentration throughout the full period.

In comparison to the work of Amiti and Heise 2021, our home and production groups correspond to their 'Export adjusted' and 'Domestic concentration' measures, respectively. Our seller concentration measure aligns with what they refer to as 'Market concentration.' All three concentration measures are significantly higher in the UK than those reported by Amiti and Heise 2021.

For the US, Amiti and Heise 2021 find that seller concentration is much lower than both producer and home concentration, with the latter two being quite similar. They observe that export adjustments have a small deconcentrating effect. In contrast, our findings show that in the UK the near reverse is true, controlling for trade concentration on average is much higher. However, this is consistent with the results of Bajgar, Berlingieri, et al. 2023, who find that trade adjustments increase the measured level of concentration in Europe. This provides us with our first stylised fact:

Proposition 2 *Seller concentration can exceed producer concentration.*

While the unweighted mean of seller concentration is consistently higher than both production and home concentration, the results are less clear when weighted by relevant absorption. Figure 2.2b presents the weighted mean of our HHI concentration measures across the sample for the years 2008 to 2019, using total absorption as the weighting factor. Specifically, the weights are based on P-X for the Home Group, P for Producers, and T for Sellers.

Once again, we observe that both producer and seller concentration levels are significantly higher than those of the home market. However, applying the weighted average reduces the overall level of all three measures: Producer and seller concentration now range between 2000 and 2500, while home concentration remains below 1500.

Notably, producer concentration remains relatively stable throughout the period, while seller and home concentration appear to move in near-opposite directions. After the global financial crisis there is a sustained increase in home concentration, but seller concentration quickly reverts to its original level. This trend reverses after 2015, with home concentration starting to decline as seller concentration begins to rise. Seller concentration is no longer consistently higher than producer concentration but is now much more volatile. But there are instance where trends in producer and seller concentration differ as well, e.g. from 2010 to 2011.

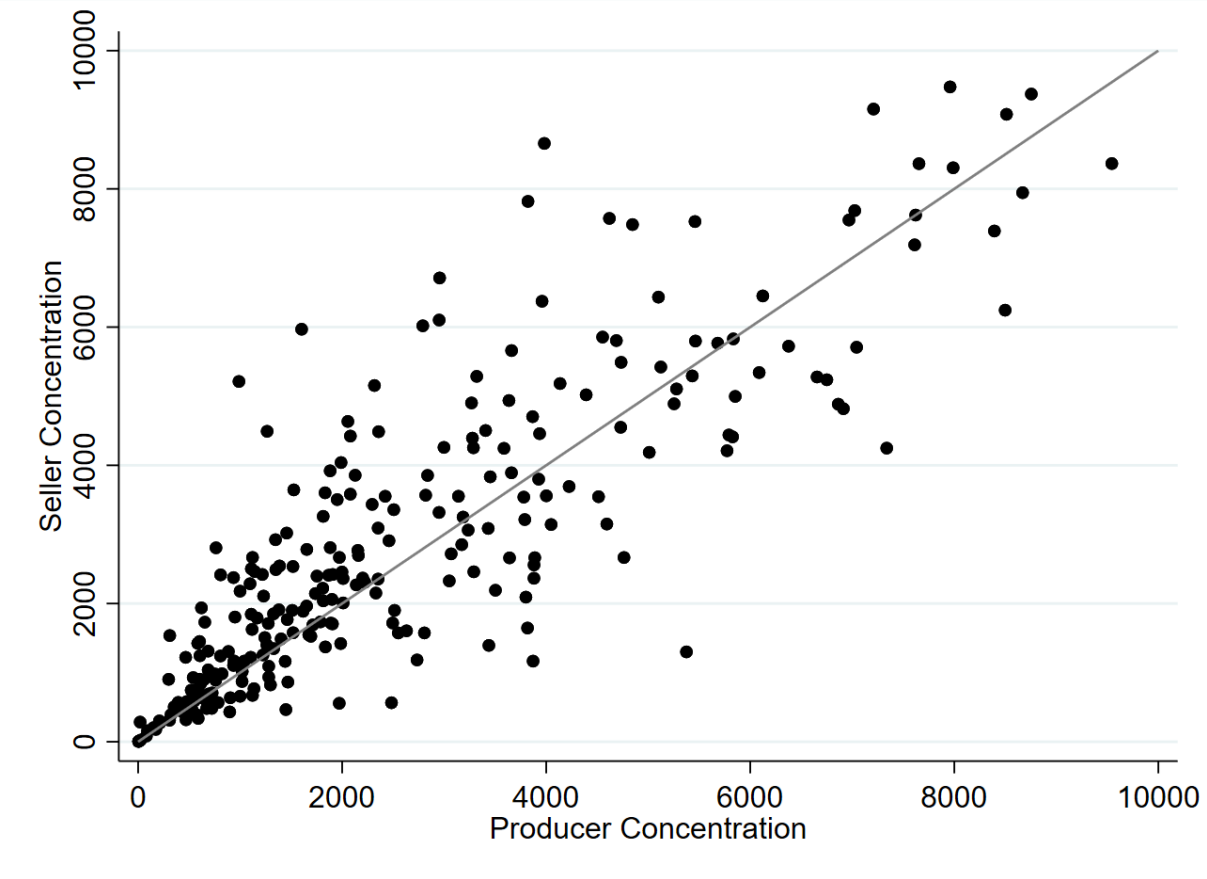
These results imply that measuring concentration in the industry instead of the market can lead to incorrect conclusions over not just the level of concentration but its trend over time. These are average figures across the 230 markets in our sample and yet still the gap between producer concentration and seller concentration is dramatic in many years. These results clearly show, that if we are interested in the level of market concentration faced by UK consumers, we must study seller concentration. Producer concentration has no correlation with the quantity and size of firms that consumers are engaging with. In addition, not incorporating imports or exports will to an large underestimation of concentration.

Of course the difference in these concentration measures is a combination of the share of imports (exports) in total output and the concentration level among said importers (exporters). As noted in Chapter One, international trade can have a concentrating affect on the market provided those foreign firms are more concentrated than the domestic producers. The difference in the level of concentration between the two groups of firms, foreign and domestic, is then magnified by the import or export share. As seen in Figure 2.1 averages share appears consistent over time. So, we now look to some industry-specific analysis.

2.4.2 Industry-Level Analysis

Figure 2.3 presents for each industry, the average level of both seller and producer concentration across our sample period. The points that lie above the 45 degree line represent the 161 SICs for which the inclusion of imports and the exclusion of exports leads to a higher degree of concentration, i.e. where concentration in the market is higher than concentration in the industry. In

Figure 2.3: Average seller v producer concentration



Each dot represents one of the 230 4 digit industries/markets and its average level of producer/seller concentration over the sample period 2008 to 2019. The line is at 45-degrees meaning those above have an average seller concentration in excess of their average producer concentration. In other words, markets in which our methodology shows concentration is on average higher than previously thought.

these markets, measuring concentration in the typical manner will lead to an underestimation of the effective level of concentration faced by consumers. For some industries, the difference is minor, but for others, it is significant. Notably, 19 of these industries would have been incorrectly classified as unconcentrated using standard benchmarks, potentially leading to them being overlooked by competition authorities. On the other hand, 10 industries which have a producer HHI in excess of 1000 have a seller HHI less than 1000. These benchmarks are often used as a first step to identify problematic industries before more detailed examinations of market power are undertaken. Our findings here suggest that some industries may be receiving unwarranted attention, while others, in which concentration is high, are being overlooked because the distinction between production and sales is not being considered. Thus we have our second stylised fact:

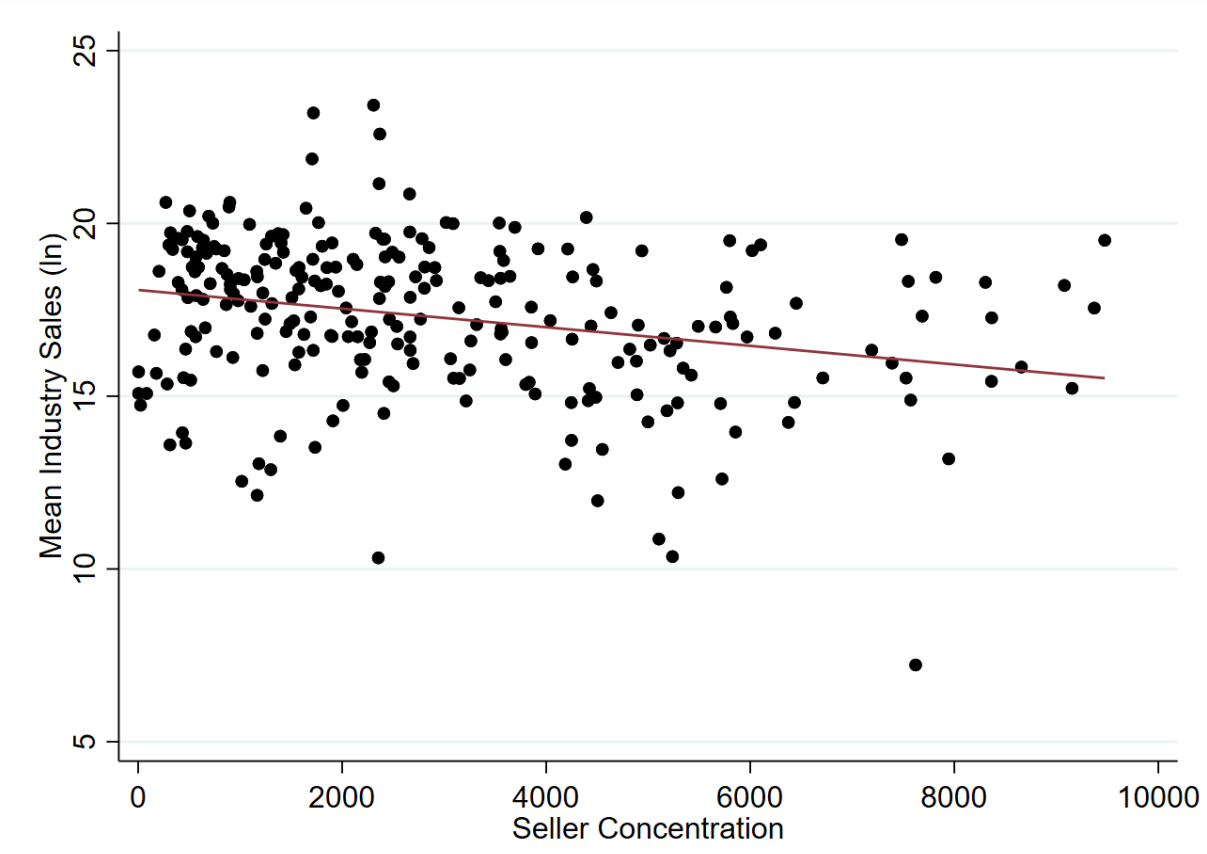
Proposition 3 *When not accounting for imports and exports highly concentrated markets can appear unconcentrated. And unconcentrated markets can appear highly concentrated.*

Again the values in Figure 2.3 are averages of the period between 2008 and 2019. In other words for 19 of these four digit industries, it is not just the case that imports lead to high concentration in some years but they have such a concentrating effect that the average levels of concentration push the market into worryingly high levels of concentration, and yet would be overlooked entirely when producer concentration is measured instead.

Figure 2.4 plots average seller concentration against average sales in the market. Broadly speaking there appears to be a slight downward trend, with smaller markets being more concentrated but there is significant variation. It is worth noting at this point that four industries in our sample are significantly larger than the rest, and together are worth 61 percent of all sales. For these four large industries however we do not see a particularly dramatic change in the level of concentration when we switch from the producer to seller concentration measure. The largest industry sees an increase in its average HHI of just 85, while the second largest one sees a rise of 167. For the third and fourth largest, imports actually have a deconcentrating effect —seller concentration being lower on average by 776 and 199, respectively.

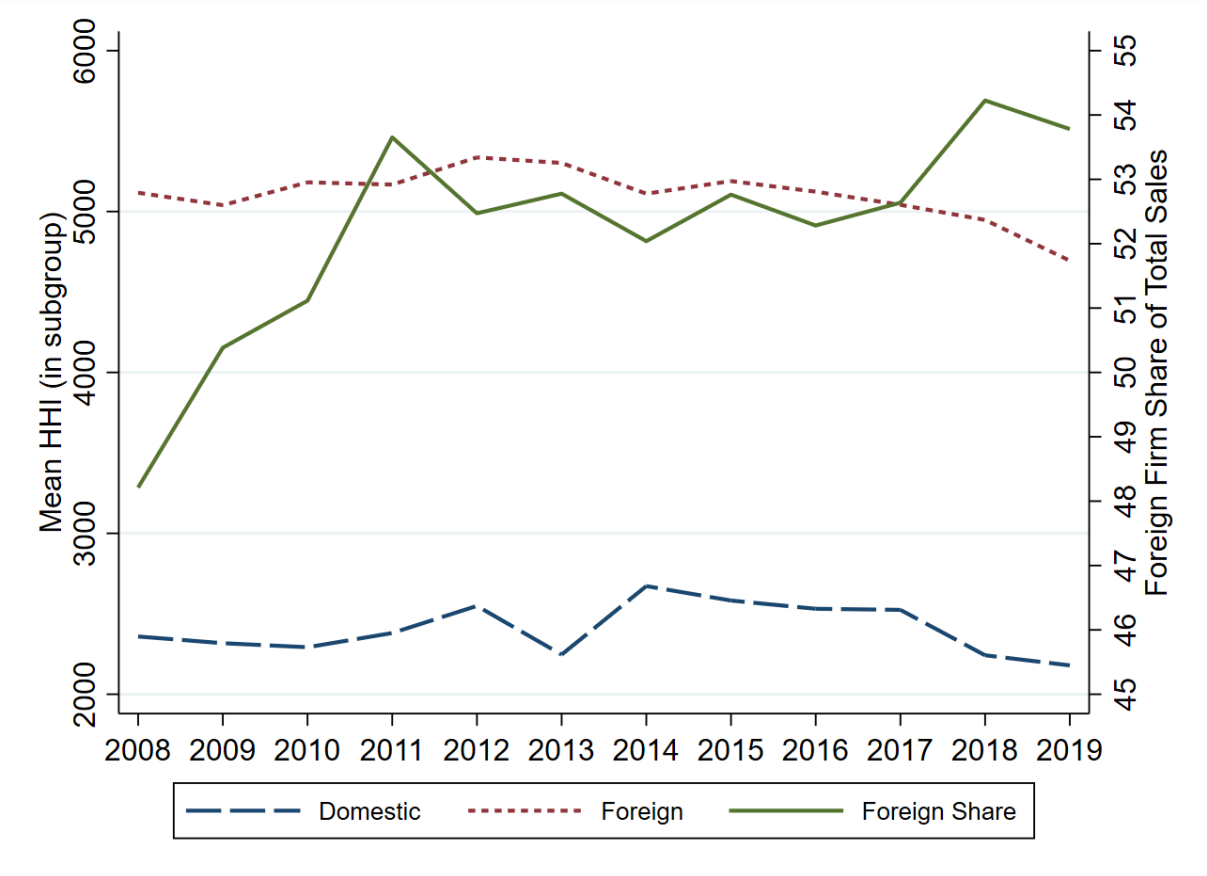
In Chapter One, our bounds approach assumed country-level monopolies by considering the upper limit of market concentration. However, when analysed at the firm level, we find that firms do, in fact, import from multiple countries, which contradicts our assumption of no multinational sourcing. On average, exporters sell to seven different countries, while importers

Figure 2.4: Market Concentration v Sales



Average value of seller concentration and market sales for each of the 230 four digit industries between 2008 and 2019.

Figure 2.5: Average concentration: Foreign v Domestic



Averages across sample. The two sub-groups are domestic firms and foreign firms, defined by those with global and ultimate ownership outside the UK and an import share exceeding 50 percent. HHI's are calculated based on domestic / foreign firm's share of total sales from domestic firms or foreign firms. Averages are unweighted means across all 230 markets.

source from six. Multinational trade is even more pronounced among the largest firms: the top 25 producers export to approximately 25 countries, while the top 25 sellers source imports from 16 different countries. This multinational sourcing means an analysis of the number of trading partners within a market, i.e. the number of countries importing into the UK market, can significantly underestimate the size of the largest firms.

Proposition 4 *Foreign sellers can be significantly more concentrated than domestic sellers.*

Using our decomposition from Chapter 1 we are able to separate overall concentration in the market into the level of concentration among domestic firms,the level among foreign firms the share of each in total sales. Figure 2.5 shows the average yearly sales concentration among domestic firms and foreign firms separately, as well as the share of foreign firms in the market as a whole. Both domestic and foreign sellers have grown less concentrated since 2014, but the level of concentration in the foreign firm subgroup is dramatically higher than among the domestic

firms, and foreign firms have become a more and more significant presence

2.4.3 Firm-Level Study

Proposition 5 *The largest firms in terms of production are not necessarily the largest firms in the market.*

The extent to which most of these industries are completely dominated by imports cannot be overstated. For 131 of the 161 markets in which seller concentration exceeds producer concentration the average import share is in excess of 90 percent. More importantly, foreign importers hold significant market positions. In over 75 percent of the SIC-year observations in our sample, a foreign importer ranks among the top five firms, and in more than half of the cases, a foreign importer is the largest firm in the market. For 43 markets, the largest firm is a foreign importer in every period, one of which is the second largest market in our sample and for nine of these the top two are foreign in every period. One industry in particular, the sixth largest in in our sample, has the top four market shares occupied by a foreign firm in every year. Overall, 151 of our markets have at least one foreign firm in their top five in every period. Interestingly of those 43, 11 have average producer concentration higher than average seller concentration, (this is also true for 47 of the 151 mentioned markets).

Clearly the largest firms in terms of production are not the largest firms in terms of sales. Table 2.2 decomposes the seller CR5 by deciles of total sales showing the breakdown by two groups: large producers and foreign firms. We define 'large producers' as those firms who are ranked top five in terms of production in a given industry in a given year. Table 2.2 shows for each decile the median number of these large producers who are also ranked top five in terms of sales. There is a somewhat inverse relationship, the largest 10 percent of industries in terms total sales have only one top five producer among their top five sellers, while the smallest 10 percent have three. Conversely, larger industries have more foreign firms as the top sellers, with the largest 50 percent of industries all having on average three foreign firms in their top five. Moreover, these foreign firms are at least comparable in size to domestic producers. In the largest 50 percent of industries, the market share of the largest domestic producer is smaller than that of at least one foreign firm.

This distinction is crucial because any analysis based on production in the market does not capture the the nature of competition in the market. A firm with a significant share of UK production may not be a significant player in the UK market. Consider for example the UK

Table 2.2: Top five sellers

sales decile	CR5		#large producers†	share		#foreign firms‡	share	
	mean	s.d.		mean	SD		mean	SD
10	70.4%	21.2%	1	15.8%	22.9%	3	47.3%	28.3%
9	67.2%	23.5%	1	13.2%	23.6%	3	46.7%	28.3%
8	67.3%	22.6%	0	8.40%	16.7%	3	46.6%	25.8%
7	69.4%	21.4%	1	10.4%	14.1%	3	47.3%	28.0%
6	70.5%	20.2%	1	11.6%	17.8%	3	48.1%	28.3%
5	73.8%	20.3%	1	15.0%	21.9%	2	45.7%	30.9%
4	76.2%	19.8%	1	20.7%	27.5%	2	42.9%	30.1%
3	79.9%	21.2%	1	25.3%	29.0%	1	38.7%	32.3 %
2	78.8%	25.3%	2	32.1%	31.5%	1	27.2%	30.2%
1	78.3%	28.0%	3	48.3%	35.8%	0	19.5%	31.9%

†Median number of firms who are ranked top five in both production and sales for a given SIC-year. ‡Median number of foreign firms among the top five sellers.

Table 2.3: Variable descriptions and descriptive statistics

variable	description	mean	SD
SellerH	seller HHI as defined above.	2824	2384
MSHARE	% total sales that are imports	86.29	27.92
FSHARE	% total sales of foreign firms	52.65	29.12
ADV	log of total advertising	14.77	2.40
R&D Engagement	% of firms engaging in R&D	28.80	9.38
CAP	log of industry capital expenditure	9.37	2.06
GROWTH	sales over previous year sales	2.23	3.26
SALES	sum of imports and home market sales (£B)	0.278	1.39

Unless otherwise stated, all statistics are calculated from SIC-year observations.

bike industry. Brompton is one of the largest producers of UK bikes with annual revenue of £130m in 2022 but exports 80 percent of its bikes. Meanwhile Specialized, an American bike manufacturer, sold £94m in the UK alone in 2021 [8]. Any industry expert will be aware of such distinctions and individual market studies are unlikely to overlook the presence of these foreign firms, but when considering multiple markets at once in more aggregated studies of an economy this aspect is often not considered. Focusing on the largest producers means we will overlook some if not a majority of the firms that possess real market power.

2.5 Determinants of seller concentration

Table 2.3 shows the descriptions and summary statistics for our outcome and control variables.

To explore the determinants of seller concentration, we begin our analysis with a straightforward estimation using the following econometric linear panel specification:

$$SellerH_{jt} = \beta_0 + \beta_1 MSHARE_{jt} + \beta_2 FSHARE_{jt} + \beta_3 ADV_{jt} + \beta_4 R\&D_{jt} + \beta_5 CAP_{jt} + \beta_6 GROWTH_{jt} + \beta_7 SALES_{jt} + \epsilon_{jt} \quad (2.1)$$

where $\beta_0, \beta_1 ... \beta_7$ are the coefficients to be estimated, the subscripts j and t represent the four-digit SIC industry and year, respectively. ϵ is the error term.

Advertising (ADV) and R&D engagement ($R\&D$) are added as independent variables for

[8] Source: Annual reports as discussed here for Brompton and for here for Specialized.

they are well known examples of endogenous sunk costs (Sutton 1991) which can be strategically managed by firms to increase consumer willingness to pay and/or act as a barrier to potential entrants and thus play an important role as determinant of concentration.

Capital expenditure (CAP) on the other hand can be considered an exogenous sunk cost, a proxy for the capital requirement firms face in a given industry. For manufacturing this is particularly important as it is another barrier to entry that firms must overcome in order to compete with incumbents. We also control for market size ($SALES$) and industry growth rate ($GROWTH$).

Our two key variables of interest are $FSHARE$ and $MSHARE$. $MSHARE$ is the percentage of total sales that isimported, whether by foreign firms, or domestic firms producing overseas. $FSHARE$ is the share of total sales due to foreign firms ($FSHARE$). As discussed above, we define foreign firms as those whose sales are more than 50 percent imports and have owners overseas. [9]

We estimate 4 specifications of Equation 2.1 to disentangle the impact of foreign firms and import penetration on market concentration. Specification 1 is our baseline model and contains only the two key explanatory variables and our controls. Specification 2, also controls for industry size in the form of total sales. Specification 3 controls for time effects with Specification 4 also controlling for industry fixed effects.

The first key result is that $MSHARE$ is highly significant and positive, in other words, higher import penetration is predicted to lead to higher levels of market concentration. More specifically our results suggest a 10 percentage point increase in import penetration increases the Seller HHI by 420, to give some perspective on this value a change in HHI from 2000 to 2500 represents a concentration from a symmetric 5 firm oligopoly to one in which the market is split even between 4 firms.

Imports may belong to foreign firms, or domestic firms with multinational production, we therefore also control for the pervasiveness of foreign firms. $FSHARE$ measures the % of total sales assigned to foreign firms, and it also positive and highly significant. A market with more foreign firms, is predicted to be more concentrated, with a 10 percentage point increase in the share of foreign firms, predicted to increase market concentration by 100. A 100 unit change in HHI being roughly equivalent to a market with 11 identical firms concentrating into one with 10. It is worth highlighting that this result controls for import penetration. For a given import

[9]Note that $FSHARE$ differs from $MSHARE$ as it does not include goods produced abroad by domestic firms but may include any production undertaken by foreign firms within the UK.

Table 2.4: Determinants seller HHI

Seller HHI	Spec 1	Spec 2	Spec 3	Spec 4
MSHARE	31.10***	31.08***	31.10***	42.10***
	(0.000)	(0.000)	(0.000)	(0.000)
FSHARE	12.03***	12.00***	11.89***	10.40***
	(0.000)	(0.000)	(0.000)	(0.002)
ADV	-56.11	-55.91	-55.44	-1.410
	(0.150)	(0.152)	(0.162)	(0.976)
R&D Engagement	16.15	16.61	16.35	25.07
	(0.323)	(0.312)	(0.317)	(0.329)
CAP	-73.74*	-75.34*	-94.15**	-67.24
	(0.058)	(0.054)	(0.027)	(0.168)
GROWTH	82.94***	82.63***	81.63***	72.05***
	(0.001)	(0.001)	(0.001)	(0.001)
SALES		33.54	38.44	71.28
		(0.662)	(0.622)	(0.495)
cons	354.4	347.9	414.6	-166.1
	(0.712)	(0.717)	(0.662)	(0.919)
Year dummies	NO	NO	YES	YES
Firm dummies	NO	NO	NO	YES
R-squared	0.1025	0.1000	0.1159	0.8365
N = 2188. J = 230 Industries. T = 11 years (2009-2019)				

p-values in parentheses.* p<0.1, ** p<0.05, *** p<0.01

share, markets with a higher share of foreign firm sales are expected to be more concentrated.

Firms that engage in international trade often do so along multiple margins and are often some of the largest firms in a market (e.g. Bernard, Jensen, et al. 2018 and others as discussed above). Therefore any firm that is importing goods to sell in a UK market is likely to be large, which would help explain our results as to why those markets with high import penetration are more concentrated. Firms selling imports likely experience posses a number of competitive advantages over purely domestic producers, including economies of scale, cheaper labour costs, access to additional market data to help identify trends early, etc. These firms will then be able to secure a greater portion of the market which could explain the positive relationship between import penetration and concentration. In addition to these foreign firms are likely more immune to domestics shocks and could receive subsidies in their home economy. These additional benefits could then explain why even when we control for import penetration, concentration is higher when we have more foreign firms.

We find no effect of R&D engagement nor advertising expenditure but see that concentration is positively related to growth. If firms expect greater profits in the future they will compete more intensely, in turn this could drive weaker firms out of the market and those unable to cope with growing demand, leaving only the largest, most productive firms remaining.

2.6 Conclusion and discussion

Concentration does not equal competition, it is merely one tool in our toolbox to help us understand market power. However because of it's intuitive nature, and ease of calculation it is one the most frequently used metrics by academics and policy makers alike. In this paper we show that measuring the wrong *type* of concentration can lead to drastically inaccurate conclusions about the structure of individual markets and trends in wider sectors of the economy as a whole. We also show that in a large number of UK markets the largest firms are foreign importers, who will be overlooked when we do not account for imports and exports to measure seller concentration. We present a series of stylised facts to show that studying production in a domestic industry tells us little about sales in the domestic market. Concentration in the the market can be much higher than production data would suggest. The largest firms may be overlooked entirely and some market can be miscategorised as unconcentrated when they are in fact highly concentrated (and vice versa). Given that competition will take place over sales,

and a When we consider where competition takes place, and potential harm to consumers, it is more appropriate to study the later. Policymakers will be much more interested in the range of goods and services their population is consuming and those concerned about market power in a given country show pay less attention to output that is sold somewhere else.

We show that when the universe of firms in a market is studied, with sufficient data on international trade at the firm level, markets can be significantly more concentrated than previously thought. What is more, if the largest firms in a market are foreign, which we often find to be the case, they may be overlooked entirely.

We analyse a sample of 230 UK four-digit markets between 2008 and 2019 and show that on average controlling for trade increases the level of concentration seen in UK markets. Shifting from *producer* to *seller* concentration by excluding exports and including imports we find a majority of markets are highly concentrated as defined by conventional anti-trust thresholds. We also find that foreign firms, who would appear minimal or be omitted without a trade correction, are in fact some of the largest firms in the market, and those largest producers who might typically receive attention from anti-trust authorities are not key players in UK markets. We find that of among the top 10 percent of producers in the domestic industry, on average only one is also top ten in terms of domestic sales.

Our results compliment the findings of Amiti and Heise 2021, but show that for the UK we find trade can have a concentrating effect, we hope more studies follow to measure *seller* as opposed to *producer* concentration in other economies and stress again the need for such a distinction. Future research should consider whether the higher levels of concentration seen when adjusting for trade translate to weaker competition in the market.

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Table 5: Lack of overlap between BSD and TIG

Firm ID	Main SIC	Turnover	Commodity Code	Exports	Imports
***26	2229	£2,071	3908	£16,995	0
***26	2229	£2,071	3801	0	£4,511
***26	2229	£2,071	3926	£1,151	£0
***26	2229	£2,071	3919	0	£4,482
***28	2740	£1,146	7303	0	£1,215
***28	2740	£1,146	8504	£7,139	0
***28	2740	£1,146	9405	£6,364	£3,476
***28	2740	£1,146	8531	0	£2,563

Notes

.1 Turnover Definition in the BSD

Table 5 shows the value of BSD turnover and TiG Import and Export data for two firms in the year 2015. Both enterprises are active at this time, and have recorded turnover figures in the BSD. Both firms are also simple enterprises, each consisting of a single reporting unit and not integrated into a larger enterprise group. For both firm's their reported turnover is less than the value of reported exports and reported imports, illustrating the lack of coverage of international trade in the BSD data. For the first firm, the commodity codes 3926 and 3919 are matched to SIC 2229 and are therefore included in our calculations of this firms sales in the UK while the commodity codes 3908 and 3801 are not. For the second firm, the commodity codes 9405 and 8531 are a match. These two firms are presented for to illustrate the issue but the lack of accounting for imports and exports in the recorded turnover of the BSD is a consistent feature in the data.

.2 SIC to HS Concordance Procedure

A three phase matching procedure is used to convert UN HS codes to UK SIC2007 codes. In the first phase codes are matched using the UN's own correspondence tables, available here. Unfortunately, this does not provide a unique one to one match in many cases and some have no match at all, therefore a second and third phase using text analysis on the classification documentation are required.

.2.1 Phase 1

As referenced above a number of correspondence tables are freely available online, provided by the UN Statistics Division. With that said, a direct conversion from HS to SIC is not provided so therefore a walk through some intermediate classification systems is achieved as follows:

- HS 2007 codes are first converted into Central Product Classification (CPC) Version 2 codes.
- In turn the CPC codes are then converted to 'International Standard Industrial Classifications of All Economic Activities' (ISIC) Revision 4 codes.
- Finally these ISIC Rev 4 codes are converted to match the European Community Classification of Economic Activities (NACE2) system.

Conveniently the UK's SIC 2007 is equivalent to the NACE 2 down to the 4 digit level meaning the walk-through to NACE gives us the match to SIC.

.2.2 Phase 2

In the second phase HS labels and SIC labels are matched at 4 digit level based on the number of shared words and phrases. The labels are initially cleaned to remove stop words and trim any exceptions mentioned before being matched.

For example, in Phase 1 we are able to match HS code 1207.99 "*Oil seeds oleaginous fruits n.e.c. in heading no. 1207 whether or not broken*" to both SIC 0126 "*growing of oleaginous fruits*" and SIC 0111 "*growing of cereals except rice leguminous crops and oil seeds*".

In this second phase, stops words such as "of" and "and" are removed, and the phrase "except rice leguminous crops and oil seeds" is removed to deal with this classes exemptions. The two SIC labels are then compared to the HS label in terms of similarity with the match to 0126 being preferred and taken forward.

.2.3 Phase 3

The third phase continues in a similar manner to phase 2 but instead of considering the 4 digit labels, the text analysis occurs based on the full industry description. For example consider the HS code 2918.21 "*Salicylic acid and its salts*" which is matched in phase 1 to SIC 2110 "*manufacture of basic pharmaceutical products*" and SIC 2120 "*manufacture of pharmaceutical*

preparations". In this case, phase 2 provides no additional information as there are no words in common outside "of". We instead need to consider the full description, provided by ONS 2009, and seen in the box below which details what is and is not included in these classes. In this phase we again trim any text referring to exclusions from said class and then our procedure identifies the word 'salicylic' in the breakdown of SIC 2110, thus providing us with a match.

SIC Inclusions and Exclusions

2110 manufacture of basic pharmaceutical products
This class includes:

- manufacture of medicinal active substances to be used for their pharmacological properties in the manufacture of medicaments: antibiotics, basic vitamins, salicylic and O-acetylsalicylic acids etc.
- processing of blood
- manufacture of chemically pure sugars
- processing of glands and manufacture of extracts of glands etc.

2120 manufacture of pharmaceutical preparations.
This class includes:

- manufacture of medicaments: antisera and other blood fractions; vaccines; diverse medicaments, including homeopathic preparations
- manufacture of chemical contraceptive products for external use and hormonal contraceptive medicaments
- manufacture of medical diagnostic preparations, including pregnancy tests
- manufacture of radioactive in-vivo diagnostic substances
- manufacture of biotech pharmaceuticals
- manufacture of medical impregnated wadding, gauze, bandages, dressings, etc.
- preparation of botanical products (grinding, grading, milling) for pharmaceutical use

This class excludes:

- manufacture of herb infusions (mint, vervain, chamomile etc.), see 10.83
- manufacture of dental fillings and dental cement, see 32.50
- manufacture of bone reconstruction cements, see 32.50
- manufacture of surgical drapes, see 32.50
- wholesale of pharmaceuticals, see 46.46
- retail sale of pharmaceuticals, see 47.73
- research and development for pharmaceuticals and biotech pharmaceuticals, see 72.1
- packaging of pharmaceuticals, see 82.92

Chapter 3

Churn at the Top: A Dynamic Indicator of Competition

Abstract: In this chapter we present a dynamic indicator of competition, namely *churn*, how many of the largest firms in a market, maintain a top position x years later. We examine the persistence of dominant market positions among leading firms in 255 four digit UK markets from 2007 to 2019. High levels of concentration can mask a turbulent competitive process among the largest firms in a market but we find churn is lower in more concentrated markets. We also find foreign firms have greater persistence at the upper end of the sales distribution and at the firm level, high markups are associated with the ability to sustain a top tier position in the market. Our results underscore the need to consider both churn and market concentration when assessing market power and competition, offering insights for policymakers concerned with competition dynamics in concentrated and globalized markets.

Keywords: Producer Concentration, Seller Concentration, Competition, HHI.
JEL classifiers: International Trade, Industrial Organisation.

3.1 Introduction and motivation

Competition is a dynamic process and so a firm's ability to exercise its market power may or may not persist over time. For policymakers the duration of a firm's dominance is a crucial component in any analysis of competition and a vital consideration in calculations of consumer harm from abuses of these dominant positions. In pharmaceuticals for example, exclusivity over a new drug is often allowed for a period of time, policymakers understanding that this incentivises innovation but that it should not endure indefinitely. The longer a dominant position is held, the more harm can be caused.

A number of influential studies suggest worrying trends in market power over the past decade (for example De Loecker, Eeckhout, and Unger 2020a, Philippon 2019, Autor et al. 2020, Weche and Wambach 2021 and OECD 2018). Despite this, the time-dimension of competition, how firms grow, shrink or sustain their position over time, has been often overlook. Evidence proposing increases in market power rarely accounts for churn, that is, whether the same firms exercise market power over time or whether they are replaced by other firms. As noted by Autor et al. 2020, while markets may increasingly exhibit a 'winner-takes-most' dynamic, if in fact those dominant firms change over time, it is easier to argue that these markets remain competitive.

Understanding the factors that enable a firm to sustain a dominant market position and exert market power over time is crucial for analysing both the competitive dynamics within a market and the broader economy. We define a simple, flexible measure of churn that complements existing indicators of competition and market power, but is unambiguous in its direction. While a market with high concentration can be competitive, it is hard to argue that a market with low churn is. If the top n firms remain in place year after year, the market is stagnant and unlikely to be competitive. We also provide some indication on the correct time frame for churn analysis, the importance of which cannot be overstated. A given market may see a complete overhaul of its largest firms every x years, and therefore may appear noncompetitive in shorter time spans. E.g. significant interest in antitrust action against IBM in 1969 and Microsoft in 2001 could be viewed as an underestimation of the churn timeframe within tech industries. As argued by Reynolds 2018, in both cases an early lead on some form of innovation was equated to an insurmountable advantage over new rivals. More recently, Google's persistent preeminent position in search engine capability, now appears to face significant challenge through the rise of AI technologies and adaptations by social media platforms (The Economist 2023).

We aim to shed light on whether the largest firms are cementing their top positions and what factors affect the likelihood a firm will maintain it's place at the top over time. Our paper contributes to the literature by showing that, for a sample of UK markets, the top end of the sales distribution is growing more and more stagnant as these largest firms are able to sustain their positions for longer and longer. We also show that foreign firms in particular have lower rates of churn and provide some preliminary results on what factors affect churn at the industry level and at the firm level. We find evidence of decreasing turnover among the largest firms in several four-digit UK markets between 2007 and 2019. Firms with the largest market shares are retaining their dominant positions for increasingly longer periods. We then explore the

factors driving market churn and find that churn is lower in markets with higher markups. In addition, within these markets, firms that charge higher markups are more likely to maintain a leading market share. We also find evidence that foreign firms are better insulated from market turbulence and have a higher likelihood of retaining top positions in the sales distribution, even when controlling for a firm's import share.

The remainder of the paper is structured as follows: Section 3.2 provides an overview of previous attempts to analyse churn; section 3.3 defines our measure of churn while section 3.4 discusses the data and methodology. Section 3.5 explores the factors influencing churn at the market and firm level. Section 3.6 concludes.

3.2 Literature Review

Numerous terms have been used throughout the literature to discuss the dynamics of firms' positions within a market with conceptual consensus on what to measure and how best to measure it somewhat lacking. In this paper, we distinguish between the phenomena of *turbulence*, defined as movement of firms into and out of the market from the phenomena of *churn*, defined as the movement of top firms into and out of the top positions, i.e., firms with the n highest markets shares.

There is extensive literature on market turbulence, with entry and exit rates commonly used as proxies for competition. Siegfried and Evans 1994 provide a summary of the early empirical work, while Geroski, Mata, and Portugal 2010 discuss the conditions necessary for new entrants to succeed. In the UK, the Competition and Markets Authority (CMA) reports that net firm entry turned negative after the 2008 financial crisis but then quickly recovered (CMA 2022). However, following Brexit, net entry and exit rates were roughly equal by 2019. Bahaj, Piton, and Savagar 2024 show a sharp increase in entry during the COVID-19 pandemic. While turbulence is important, if entry and exit are concentrated at the bottom end of the sales distribution, they reveal little about the broader competitive dynamics of a market.

Numerous methods have been proposed to study the persistence of leading firms in a market. Early attempts to study the evolution of market shares over time involved probabilistic modelling based around some explicit growth process to predict how firms would grow / shrink in comparison to one another over time (Hart and Prais 1956, Adelman 1958 and Simon and Bonini 1958). Later, correlations between firm market shares over time were used to investigate

indicators of competition, with some evidence of high correlations between past and current market shares leading to lower levels of growth in the market overall (Gort 1963), and higher levels of concentration (Grossack 1965) S. W. Davies and Geroski 1997 highlight the disconnect between concentration and churn, a constant level of concentration can hide considerable turbulence amongst the market shares of surviving firms.

R. E. Caves and Porter 1978 were among the first to analyse not only the absolute changes in firm market shares over time but also the relative changes, meaning the shifts in market share compared to initial shares. This approach was subsequently employed by Kato and Honjo 2006, who found that leading Japanese manufacturing firms maintain more stable industry shares in highly concentrated markets, while industry growth can lead to instability in market shares. Similarly, Sakakibara and Porter 2001 discovered that higher levels of churn can boost industry exports.

A significant contribution to this literature is the work of Cable 1997, who proposed the Market Mobility Index (MMI), which measures the sum of squared changes in market shares. The MMI can range from zero, indicating that all firms maintain their market shares from one period to the next, to two, which occurs when one monopoly is entirely replaced by another. The classification of what constitutes high and low levels of market mobility in the MMI is subject to debate. To illustrate its applicability, consider the following example. Imagine a firm enters a market and captures a 50 percent market share within a single period. If this scenario involved an incumbent monopolist, it would result in an MMI of 0.5. In contrast, if the same situation occurred in a symmetric duopoly, where both incumbents' market shares shrink to 25 percent after the new firm enters, the MMI would be 0.375. More recently, Van Kranenburg 2002 and Björkroth and Grönlund 2015 have emphasised how the MMI can be decomposed to separately analyse the effects of entry and exit versus firm persistence on market concentration.

Sutton 2007 seeks to formalise the threshold at which market persistence becomes a cause for concern by comparing it to a random walk benchmark. He finds that, in some industries, persistence in maintaining a top position is a consistent feature; however, the characteristics that define these industries remain unclear. Sutton also emphasises the significance of the so-called 'scaling relationship' in understanding market share dynamics. At its core, this concept suggests that shocks to a firm's market share are influenced by the size of that market share to begin with.

Our paper is most closely related to two recent studies. Honjo, Doi, and Kudo 2018 examine

the rate of replacement among the top three firms and find that churn in this group is more likely to occur in industries that are either growing or declining, as well as in those with high levels of R&D spending. Meanwhile, Bessen et al. 2020 measure churn by assessing the probability that a firm loses its top-four ranking from one year to the next, which they refer to as the 'replacement hazard.' They also analyse the probability that firms ranked fifth through eighth gain a top-four position, termed the 'leapfrogging hazard.' Their findings indicate lower market share stability when markups are higher and greater stability when firms invest heavily in software and other intangible assets. However, neither study distinguishes between sales and production as we do in Chapters 1 and 2, nor do they utilise data on the entire universe of firms within the relevant market.

S. W. Davies and Geroski 1997 and Geroski and Toker 1996 both argue that concentration metrics must be considered alongside measures of churn, as high levels of concentration can exist both when market shares are turbulent and when they are stagnant. These papers also find some evidence that high investments in advertising and R&D protect against churn and are associated with the largest firms maintaining their market shares over time.

A recent study by the UK's Competition and Markets Authority not only examined churn but also assessed profit persistence, finding some evidence that competition may have weakened at the sector level CMA 2022. However, the study of churn remains an underdeveloped area in our field. As noted by Stephen Davies 2021 and Philippon 2019, it is still common to rely solely on static concentration measures without considering churn.

Our paper contributes to this literature in two key ways. First, we introduce a straightforward measure of churn that can be adjusted to examine different market segments, offering a more intuitive understanding of instability in firms' market shares. Second, we are the first to provide churn data based on sales among the entire universe of firms selling to consumers within a given country, rather than relying on production shares that are subsequently exported to multiple markets.

3.3 Measures of Churn

3.3.1 Churn Index

As discussed above, a market can be concentrated yet still competitive if the firms with the largest market shares frequently change and replace one another, preventing any single firm from

maintaining a persistent position near the top. This concept has been referred to by various names in the literature; here, we adopt the term 'churn' and present our measure accordingly.

For a given year t, $\text{Churn}^n_{t(x)}$ represents the proportion of the top n firms by market share in year t, that have not maintained their position in the top n over the previous x years. As an example, a value of $\text{Churn}^5_{2019(3)} = 0.2$ tells us only one firm of the top five in 2019 (20 percent) has changed since 2016, the other four, have remained top five in every year since 2016. More formally we define $\mathcal{A}^n_t$ as the set of the top n firms by market share at time t. The churn index for year t, over x years, is defined as:

$$\text{Churn}^n_t(x) = 1 - \frac{|\mathcal{A}^n_t \cap \mathcal{A}^n_{t-1} \cap \mathcal{A}^n_{t-2} ... \cap \mathcal{A}^n_{t-x}|}{n}.$$

The variable can take any value between between zero and one depending on the number of top firms, n, we are considering. A value of zero tells us that the top n firms have not changed in the last x years. And a value of one, tells us that all of the top n firms have changed at least once, i.e., there is a complete churn.

The simplest churn measure is the one-year top firm churn, denoted as, $\text{Churn}^1_{t(1)}$. This is a binary variable that equals one if the top firm has changed since the previous year, and zero otherwise. Similarly, $\text{Churn}^5_{t(1)}$ represents the one-year churn rate for the top five firms, indicating the proportion of these firms that have changed within a year. In contrast, $\text{Churn}^5_{t(3)}$, measures the three-year churn rate for the top five firms, reflecting the proportion that have changed over the past three years.[1]

3.3.2 Market Share Instability

We also use two measures of market share instability adopted from previous literature (see R. E. Caves and Porter 1978, Kato and Honjo 2006, Sakakibara and Porter 2001), and compute those for all firms in the market. They are the absolute and relative market share stability defined, respectively, as follows:

$$\text{AMSI}_{jt} = \sum_{i=1}^{I} \left| S^i_{jt+1} - S^i_{jt} \right| \tag{3.1}$$

[1] CMA 2022 uses the term 'rank persistence,' which is equivalent to 1 - $\text{Churn}^{10}_{t(3)}$. However, their analysis is limited to the sector level and focuses only on the top ten firms over the three-year timeframe.

$$\text{RMSI}_{jt} = \sum_{i=1}^{I} \left| \frac{S^i_{jt+1} - S^i_{jt}}{S^i_{jt}} \right|, \tag{3.2}$$

where S^i is the market share of firm i. Each measure is defined for a given industry j and year, based on the changes in firms' shares over time. By their construction, the absolute and relative measures have an upward and downward bias respectively for highly concentrated markets, thus we use both as a robustness check against our measure of churn defined above. It is worth noting that AMSI is bound between 0 and 2 but the RMSI can take much larger values when there is a dramatic rise or fall in a firm's share.

One issue with both *RMSI* and *AMSI* is that they are not defined for *disrupting* firms. i.e. if a firm enters the market next year it will have an S^i_{jt+1} but it's S^i_{jt} such firms are omitted from the both indices, this disruptor would be capture by our *Churn* index which is another advantage of our methodology.

3.4 Data and Methodology

Data on firm ownership, industrial classification, employment and turnover is provided by the UK Business Structure Database (BSD). The BSD is a yearly extract of the Inter-Departmental Business Register (IDBR), created to provide a panel of UK firms over time. It covers any firm registered for VAT or PAYE purposes, covering 87 percent of UK employees and the associated economic activity (Lemma et al. 2023).[2]

We complement this data with the Trade in Goods (TiG) database, which provides firm-level imports and exports by country of origin/destination and commodity code. This enables us to focus on churn among sellers rather than producers by excluding exports and including imports in our analysis. The TiG data is derived from HMRC's Overseas Trade Statistics (OTS), collected for administrative and tax purposes.[3]

Firm-level balance sheet data is accessed through the UK's Annual Business Survey (ABS). The ABS is conducted by the ONS annually, and is the primary source of information on the structure, conduct and performance of firms. It crosses most business sectors, collecting financial data from businesses' end-year accounts, including turnover, wages and salaries, purchases of goods and services, stocks and capital expenditure, and is widely used by government bodies

[2]For more information on the BSD, see the Integrated Data Service here.

[3]These datasets were accessed through the UK Office for National Statistics' Secure Research Service and are therefore confidential, limiting our ability to disclose specific industry details to avoid potential identification.

such as the Bank of England.[4]

The sampling frame for the ABS is any firm registered on the UK's Inter-Departmental Business Register (IDBR), which are 2.6 million businesses, covering nearly 99 percent of UK economic activity. Around 62,000 firms are sampled at the reporting unit level from this population each year, and given a detailed question to complete. The selection process is semi-random with firms first grouped into sample cells based on employment band, SIC and country of operation (England, Scotland or Wales). Cells that contain the largest firms in terms of employment (which for most means markets means those with > 250 employees) are sampled every year, for our purposes this means each SIC has continuous coverage of the largest employers. All other firms are then stratified based on their employment band (e.g. 0-9 employees, 10-19, 20-49, etc) with a random sampling drawn every 2 years.[5] The end result is coverage of the largest employers in every period and a random sampling of the smaller firms in each SIC, from which we extract key firm-level balance sheet information, such as R&D participation, advertising and capital expenditure, and use the ABS information to generate our estimates of markups and total factor productivity (TFP). For the TDP and markups estimation our key variables are as follows: output is measured as approximate gross value added; labour is the number of employees in service of the enterprise; capital is the value of total net capex (excluding Not Yet In Progress); while materials covers the total cost of goods and all raw materials used in the running of the business.

Firm-level variables are aggregated to the enterprise level, and markets are measured at the four-digit level using the UK's Standard Industrial Classification system 2007 (SIC).[6] We follow the concordance procedure from Chapter 2 to merge the BSD, TiG and ABS data and only include sales that exist within a firm's main SIC. Our final sample spans the years 2007 to 2019 and covers 255 five-digit industries with total sales of £76.4B for 2019.

3.4.1 Markup Estimation

We estimate markups using the production function approach of De Loecker and Warzynski 2012 (henceforth DLW). Their methodology has been widely adopted throughout the modern empirical IO literature and beyond (for example Amiti, Itskhoki, and Konings 2019, Autor et al. 2020, Mrtens and Mottironi 2023, Lu and Yu 2015 and De Loecker, Pinelopi K Goldberg, et al.

[4] More information on the ABS is available from the ONS here.
[5] For more detail see the ABS technical report.
[6] A full breakdown of the structure of the SIC can is provided by the ONS and can be found here.

Table 3.1: Industry level variables

Definitions and descriptive statistics

Variable	Definition	Mean	SD	Min	Max
$Churn^{10}_{t+1(1)}$	1 Year Top 10 Churn	25.45	14.35	0	100
$Churn^{10}_{t+3(3)}$	3 Year Top 10 Churn	45.41	23.42	0	100
AMSI	Absolute Market Share Instability Index ×100 (top 10 firms only)	23.66	19.44	0.08	151.90
lRMSI	Log Relative Market Share Instability Index ×100 (top 10 firms only)	5.84	0.87	2.32	12.75
IndMU	Mean Markup per SIC-year	1.442	0.175	0.454	2.879
ImpPen	Import Penetration	88.11	25.44	0	98.96
CR10	Top 10 Firm Concentration Ratio	84.61	19.29	6.55	100
DIST10	Relative Size of 10th Ranked firm to 11th Ranked	1.34	1.00	1.00	31.17
IndADV	Log of Total Advertising Expenditure	14.95	2.28	6.91	21.26
IndR&D	Industry R&D Engagement	27.46	30.56	0	100
IndCAPEX	Log of Total Capital Expenditure	9.48	1.91	0.69	14.90
GROWTH	Market Sales Growth (Current sales over previous year sales)	1.10	1.24	0.002	42.67
SIZE	Market Size (Sales in £bn)	0.297	1.43	0.00	23.64

Unless otherwise stated, all variables are defined for each SIC-year observation. Values are reported to 2 decimal places. E.g. minimum market size in sample is £89,000. For the results below we scale AMSI by a factor of 100 to resize our coefficients therefore AMSI is now bound between 0 and 200. We do the same for RMSI before taking the log.

2016). The DLW method provides an alternative to demand-side markup estimation, which requires an explicit demand system and additional behavioural assumptions of price setting, in combination with very detailed market-level data on prices, quantities sold, and product characteristics (De Loecker 2011).

In essence, the DLW approach adapts the markup estimator first developed by Hall 1986 and Hall 1988, and applies it at the firm-level by using the so-called proxy approach literature developed by Olley and Pakes 1996, Levinsohn and Petrin 2003 and Ackerberg, K. Caves, and Frazer 2015 to deal with unobserved productivity shocks when estimating production functions.

For the sake of brevity we refer the reader to De Loecker and Warzynski 2012 for a full derivation, but the main insight is that in defining markups as the price-marginal cost fraction, it is possible to rewrite first-order condition of a cost-minimising firm as

$$\mu_{it} = \theta_{it}^{X}(\alpha_{it}^{X})^{-1} \tag{3.3}$$

where μ_{it} is firm i's markup in period t, θ_{it}^{X} is the output elasticity of an input X_{it}, and α_{it}^{X} is the share of firm expenditure on the input X_{it} in total sales. As noted by De Loecker and Pinelopi Koujianou Goldberg 2014 the theory is that for any variable input free of adjustment costs, the markup drives a wedge between the input's output elasticity and the input's revenue share. While the revenue share can be observed in the data, the output elasticity must be estimated, in this case using the proxy approach in the spirit of Ackerberg, K. Caves, and Frazer 2015.

Full details of the DLW procedure can be found in Appendix .1, but for our work we adopt the translog production function as outlined in the main specification of DLW.

3.4.2 TFP Estimation

We estimate total factor productivity following the proxy approach developed by Olley and Pakes 1996, Levinsohn and Petrin 2003 and Ackerberg, K. Caves, and Frazer 2015. In essence the methods use variation in some observed input to deal with unobserved productivity shocks when estimating production functions.

Full details of the proxy approach procedure can be found in Appendix .3, but estimation occurs in two stages. In the first, output is regressed non-parametrically on some composite function that represents firm productivity as function of inputs and proxies. More specifically,

the method aims to identify ω, which covers productivity shocks not observable to the econometrician but realised by the firm in a manner that allows them to adjust input decisions. The intuition, as outline in the original work by Olley and Pakes 1996 being that if a firm knows it will be more productive in the next period it will invest more in the current period. This can then be used to back out an estimate of that element of the firms productivity, allowing us to deal with the endogeneity of such actions by the firm in production function estimation. The second stages then uses the estimates of the remaining error term and the composite function to estimate coefficients for each of the inputs, typically done via a GMM method.

For our work we adopt the method of Levinsohn and Petrin 2003 and use materials as our input proxy and apply the Ackerberg, K. Caves, and Frazer 2015 correction for potential collinearity issues. We approximate the composite function with a 4th order polynomial with full interactions.

3.4.3 Trends

Figure 3.1 presents, for the years 2008 to 2019, the average churn across our sample of 255 four-digit UK SIC markets. The six measures presented are the churn amongst the top five, top 10 and top 25, for both the one year and three year time frames. The thinner lines represent the $\text{Churn}^{5}_{t(1)}$, $\text{Churn}^{10}_{t(1)}$ and $\text{Churn}^{25}_{t(1)}$ while the thicker lines are the $\text{Churn}^{5}_{t(3)}$, $\text{Churn}^{10}_{t(3)}$ and $\text{Churn}^{25}_{t(3)}$. To aid interpretation, consider the $\text{Churn}^{10}_{t(3)}$ measure, represented by the thick short-dashed line. It starts at just over 60 percent in 2010 and ends around 45 percent in 2019. This means that, on average, six of the top 10 firms in 2010 had changed at some point since 2007, while the other four firms had maintained a top 10 position continuously since 2007. By 2019, the number who had stayed in place was on average 5.5, meaning only 45 percent of the top 10 firms had changed since 2016.

The first notable pattern in the data is that churn tends to be higher among larger firms, i.e. churn is higher in higher rank classes. For both time frames (one year and three years), churn rates are higher for the top five firms compared to the top 10, and the top 10 rates are generally higher than those for the top 25. In other words, firms move in and out of the top five more frequently than the top 10, and the top 10 change more often than the top 25. This suggests that while firms may lose their leading position, they typically don't fall far and still retain a significant market share.

The second key pattern in the data is the noticeable difference between the one-year and

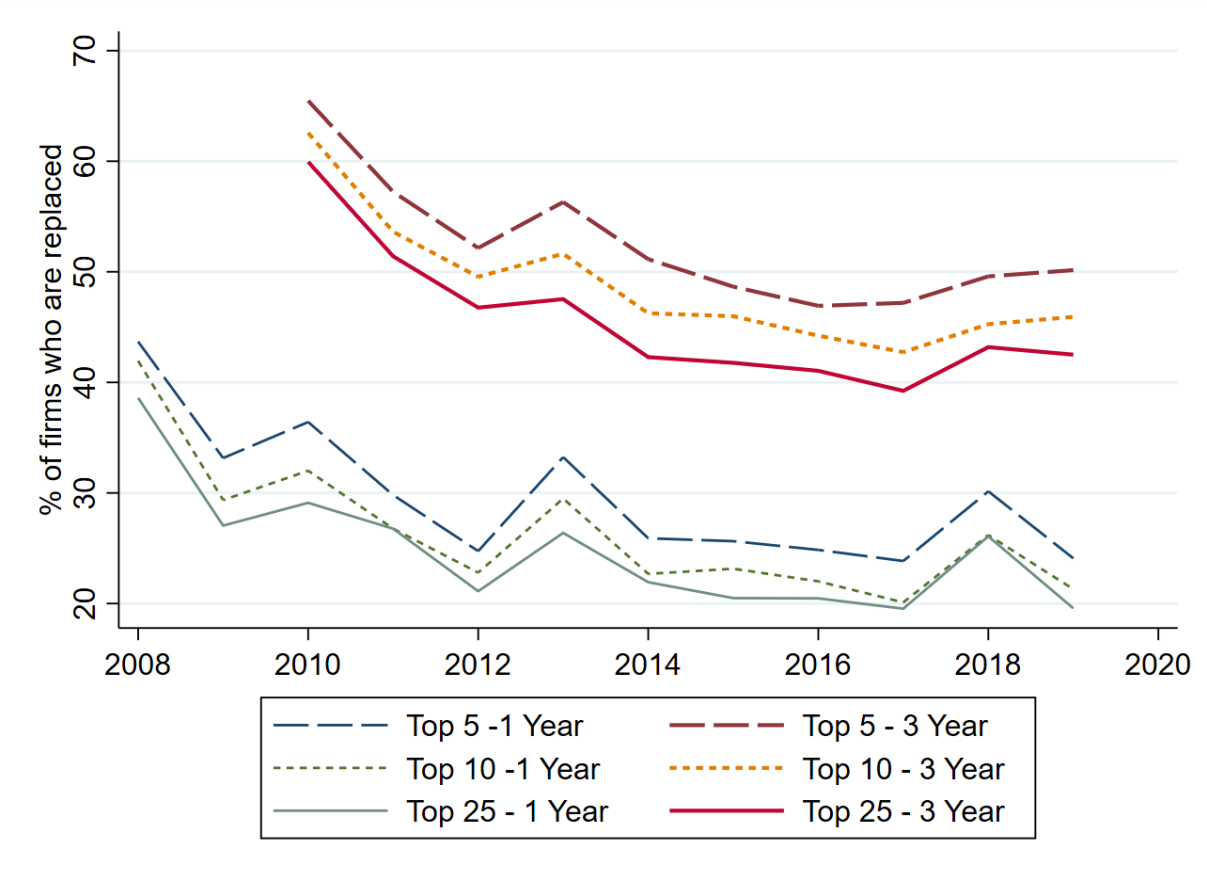
Table 3.2: Firm level variables

Definitions and descriptive statistics

Variable	Definition	Mean	SD	Min	Max
Sustain^5(1)	Firm holds a top five rank in both year t and year $t+1$	0.198	0.398	0	1
Sustain^5(3)	Firm holds a top five rank from year t through year $t+3$.	0.137	0.344	0	1
Markup	Firm Level Markup (%)	154.062	26.678	14.356	1670
TFP	Firm's Total Factor Productivity	14.482	0.801	3.810	21.424
Foreign	Foreign Firm Dummy	0.374	0.484	0	1
M Share	% of Firm Sales that are Imported	65.423	42.987	0	1
Age	Years since Firm's birth	31.642	10.193	2	45
Capex	Firm Net Capital Expenditure (£10mn)	0.622	4.136	0.001	206.140
Sales	Firm Sales (£10mn)	2.857	22.629	0.001	646.561
AdvExp	Firm Expenditure on Advertising (£10mn)	0.292	1.499	0	33.226
R&D	Dummy Var - Firm Engages in R&D in that year	0.167	0.373	0	1
Empees	Number of Employees ('000s)	0.726	1.418	0.001	30.912

We consider 3366 firms across 255 four-digit industries between the years 2008 and 2019. The unbalanced panel considers only those firms that hold a top five market share for at least one period in their market. Firm markups are scaled to percentages i.e. a value of 160 is a markup of 1.6.

Figure 3.1: One and three year churn measures



The three rank classes —top 5, 10, and 25 —represent churn among the largest firms by market share in each group. The two time frames, one year and three years, indicate how many firms from the top x in a given year have maintained their position within that rank class over the preceding one or three years, respectively. The sample covers the period from 2007 to 2019 across 255 four-digit industries.

three-year time frames. For any given year, the proportion of top five firms that have been replaced at least once over the past three years is higher than the proportion replaced in just the past year. The same holds true for the top 10 and top 25 firms. While this is not surprising, it underscores the importance of selecting the appropriate time frame for churn analysis. Year-to-year churn may appear low when firm rankings are relatively stable, as it often takes several years for significant changes to occur at the top. This is particularly important when interpreting AMSI and RMSI values, as they are measured on a yearly basis.

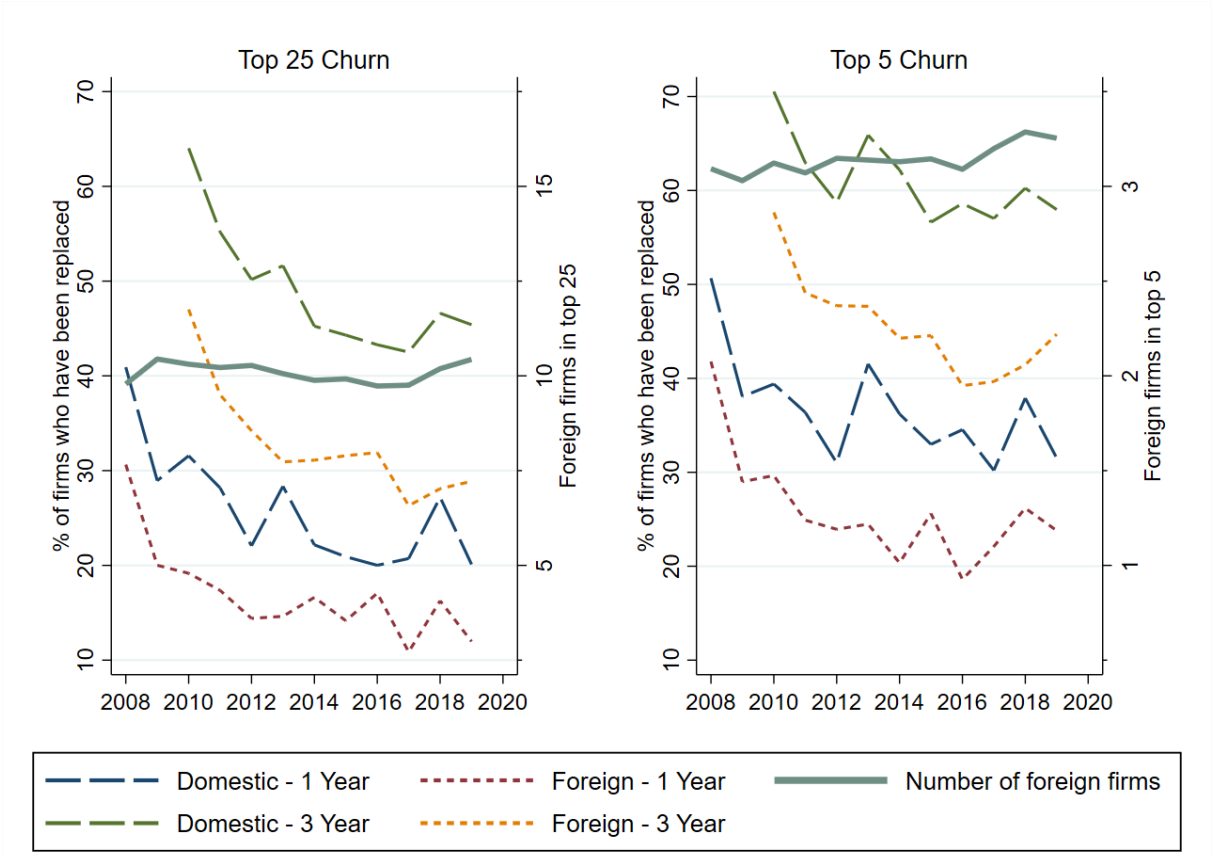
A third point of note in Figure 3.1 is that within a given time frame the three churn measures move in a similar manner, increasing or decreasing in tandem for almost every year. There are a few exceptions, e.g. in 2015 the $Churn^{10}_{t(1)}$ increased slightly while the $Churn^{25}_{t(1)}$ decreased, in other words the decreased churn amongst the firms ranked 11 through 25 was sufficient to offset the higher level of churn seen amongst the top 10.

Finally, the most striking feature of the data is that all our measures of churn have decreased over time. For our sample at least, this suggests the top firms are becoming more entrenched and are more likely to maintain their ranking in terms of market share.

Figure 3.2 separates our churn measure into foreign and domestic firms among the top five and top 25. We define a foreign firm as one which has immediate and ultimate ownership outside of the UK and for which more than 50 percent of its total sales are imported. The $\text{Churn}^{5(Domestic)}_{t(1)}$ tells us the rate of replacement amongst domestic firms in the top five. A value of zero means there has been no change in the identity of the domestic firms among the top five since the previous year. Conversely, a value of one means that none of the domestic firms that are top five in the current year were top five in the previous year. In a similar manner, the $\text{Churn}^{25(Foreign)}_{t(3)}$ tells us how many of the foreign firms in the top 25 have changed over the past three years. If $\text{Churn}^{25(Foreign)}_{t(3)} = 1$, then none of these large foreign firms have been able to hold on to a top five spot for each of the past three years. If $\text{Churn}^{25(Foreign)}_{t(3)} = 0$, then all of the foreign firms in the top five have been among top five for the last three years.

The two measures, $\text{Churn}^{n(Domestic)}_{t(x)}$ and $\text{Churn}^{n(Foreign)}_{t(x)}$, are inherently dependent on the number of domestic and foreign firms within a given rank range. If there are no foreign firms among the top n firms, $\text{Churn}^{n(Foreign)}_{t(x)}$ cannot be defined. Similarly, $\text{Churn}^{n(Domestic)}t(x)$ is undefined if all of the top n firms are foreign. Figure 3.2 also shows the average number of foreign firms among the top five and top 25 for each market-year. Interestingly, across our 255 markets, the average number of foreign firms remains relatively stable, with about 10 of the 25

Figure 3.2: Foreign v domestic firm churn



We define a foreign firm as one that has both immediate and ultimate ownership outside the UK and imports more than 50 percent of its total sales. The rank classes of 25 (left) and five (right) represent churn among foreign and domestic firms within the top 25 and top five largest firms by market share, respectively. The two time frames —one year and three years —indicate how many firms within the top x in a given year have maintained their position in that rank class over the previous one or three years, respectively. We also include the average number of foreign firms among the top 25 and top 5 in a given year. This analysis covers the period from 2007 to 2019 across 255 four-digit industries.

largest firms and three of the top five being foreign. For instance, in a given year, if an industry has three foreign firms among its top five, and $\text{Churn}_{t(3)}^{5(Foreign)}$ is 33 percent, this means only one of those three foreign firms has maintained a top-five position over the past three years. However, this measure does not provide any information about the two domestic firms, which may have remained unchanged.

Even with the distinction between foreign and domestic firms, Figure 3.2 shows that churn is higher for larger firms and over longer time frames, mirroring the overall churn levels presented in Figure 3.1. Notably, churn is lower for foreign firms in both the top 25 and top five rankings. This is particularly striking given that, among the top 25 firms, the majority are domestic, while in the top five, the majority are foreign. Regardless of whether they constitute a majority or a minority in a given rank class, foreign firms demonstrate greater persistence compared to their domestic counterparts.

Large foreign firms likely export to multiple countries in addition to the UK and therefore one reason for their stability may be that they are more robust to domestic shocks, able to smooth out losses over the multiple different countries they sell in. They may also have larger domestic economies on which to rely, with better labour market conditions or access to better production technologies. They could also receive support from their home economy in the form of subsidies, or simply have more secure logistics and better researched marketing endeavours due to their multinational scope. All of these could give the foreign firms an advantage over their domestic counterparts, allowing them to sustain their market positions more easily. It could also be that given the fixed costs of entering the market in a given country, foreign firms will work harder to recuperate this these entry fees while smaller domestics firms are more transitory.

3.5 Examining the Correlates of Churn

3.5.1 Market-Level Analysis

We now consider the factors correlating with churn at the industry level, and estimate the following equation:

$$\begin{aligned}\text{Churn}_{jt(x)}^{10} = \beta_0 + \beta_1 \text{IndMU}_{jt} + \beta_2 \text{ImpPen}_{jt} + \beta_3 \text{CR10}_{jt} + \beta_4 \text{DIST10}_{jt} + \beta_5 \text{IndADV}_{jt} + \\ + \beta_6 \text{IndR\&}D_{jt} + \beta_7 \text{IndCAPEX}_{jt} + \beta_8 \text{GROWTH}_{jt} + \beta_9 \text{SIZE}_{jt} + jFE + tFE + \epsilon_{jt}\end{aligned} \tag{3.4}$$

Table 3.3: Churn Results

	$Churn^{10}_{t+1(1)}$			$Churn^{10}_{t+3(3)}$		
	1-1	1-2	1-3	2-1	2-2	2-3
Key variables						
IndMU	-1.074***	-0.689*	-1.132**	-1.538***	-0.912*	-1.099
	(0.006)	(0.077)	(0.016)	(0.004)	(0.095)	(0.112)
ImpPen	-0.000467	-0.0147	0.0410**	-0.0549	-0.0664*	-0.0771*
	(0.831)	(0.503)	(0.042)	(0.148)	(0.081)	(0.082)
Control variables						
CR10	-0.131***	-0.121***	-0.0593	-0.153***	-0.140***	-0.0687
	(0.000)	(0.000)	(0.430)	(0.002)	(0.004)	(0.495)
Dist10	-0.892***	-0.807***	-0.566**	-0.979**	-0.931**	-0.778**
	(0.002)	(0.005)	(0.029)	(0.019)	(0.023)	(0.045)
IndADV	-0.325	-0.403*	-0.248	-0.240	-0.435	-0.170
	(0.170)	(0.085)	(0.511)	(0.477)	(0.201)	(0.717)
IndR&D	0.591***	0.182	0.00801	0.716***	-0.00652	0.00890
	(0.000)	(0.933)	(0.748)	(0.000)	(0.819)	(0.782)
IndCAPEX	-0.520*	-0.354	-0.269	-1.093***	-0.878**	-0.495
	(0.079)	(0.228)	(0.496)	(0.006)	(0.028)	(0.351)
IndGRW	0.00713	0.00842	0.0100**	-0.0145	-0.0112	-0.0180
	(0.272)	(0.304)	(0.044)	(0.352)	(0.507)	(0.410)
IndSIZE	0.239	0.195	0.570	0.667***	0.666***	1.018**
	(0.377)	(0.506)	(0.106)	(0.000)	(0.000)	(0.046)
cons	49.73***	54.40***	49.19***	84.38***	90.41***	86.45***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year Dummies	NO	YES	YES	NO	YES	YES
Ind Dummies	NO	NO	YES	NO	NO	YES
N	2032	2032	2032	1616	1616	1616
R-Squared	0.0518	0.0852	0.0889	0.0751	0.107	0.109

The dependent variables $Churn^{10}_{t+1(1)}$ and $Churn^{10}_{t+3(3)}$ are measured with a lead of 1 and 3 years respectively while the explanatory variables are defined for the current year. Sample of 255 four digit markets across 2007 to 2019. p-values in parentheses ***, ** and * indicate significance at the 1, 5 and 10 percent levels respectively

where $\beta_0, \beta_1 ... \beta_9$ are the coefficients to be estimated, the subscripts j and t represent the four-digit SIC industry and year, respectively. The last three terms, are industry fixed-effects, time fixed-effects, and the error term.

$\text{Churn}^{10}_{t(x)}$, defined above, is measured at the the one and three year time frame and represents the percentage of the top 10 firms by market share in year t that changed in the last x years. In our sample, across 255 industries, and between the years of 2007 to 2019, the mean $\text{Churn}^{10}_{t(1)}$ is 25 percent meaning that, on average, in any given year only a quarter of the top largest firms have changed since the previous year. Over the three year time frame this rises to about 45 percent. ImpPen is the percentage of market sales that are due to imports. IndMU is the mean markup per industry year calculated using the De Loecker and Warzynski 2012 methodology.

Table 3.3 presents the results from our estimation of Equation 3.4 for both one-year and three-year time frames. Specifications 1-1, 1-2, 2-1, and 2-2 provide evidence that higher market concentration is associated with lower levels of churn. Specifically, a 10 percentage point increase in the CR10 for the current year is predicted to decrease $\text{Churn}^{10}_{t+1(x)}$ by 1.21 percentage points over one year and by 1.4 percentage points over three years. This can be easily explained if high concentration is taken as a proxy for weak competition. When the largest 10 firms in a market control more of the market, they will face weaker competition from the remainder of firms and potential entrants. Of course those 10 may compete heavily with each other, which raises conceptual issues about the definition of competition. Is a market with two firms who constantly replace each other, swapping a majority share of the market year in and year out, more competitive than one in which, the same market shares are held by the top 2 firms but their identity is constantly changing as disruptors enter and incumbents fall away? The matter is open for debate but our results would suggest, a market with a smaller number of larger firms, sees those at the top as less likely to be replaced, which may in turn dis-incentivise innovation or competitive pricing, ceterus paribus. All specifications consistently show a significant negative effect of Dist10, as expected, the more dramatic the gap between the 10th and 11th largest firms, the harder it will be for the 11th largest firm to displace one of the top ten. We find some evidence that Churn is higher in markets with higher R&D participation, the idea that markets where more firms engage in research and development are predicted to have greater churn at the top is perhaps unsurprising. In the extreme, if every firm is striving to innovate and develop new products and technologies, there will be considerable churn as breakthroughs are made by different firms over time. A market in which a smaller number of firms look to innovate in this

manner will see those firms less likely to move out of the top positions. There is some evidence that high growth industries see higher rates of churn but only over the 1 year time frame. If the potential for future profits is greater at a given market share, firms may compete more intensely and thus there will be more churn amongst the top. This could encourage not just smaller incumbents but potential entrants as well. The fact it is significant only over the 1 year time frame may reflect the fact that firms will capitalise quickly on positive short term trends, but other factors become more important over longer term time frames. Interestingly we find a positive effect of market size on churn but only over the 3 year time frame. All else being equal a larger market today is predicted to have a larger number of the top 10 firms remain in position after 3 years. A £1bn increase in market sales equates to a 1 percentage point higher rate of churn over three years. In larger markets barriers to displacement may be higher, thus taking more time to overcome, but the potential rewards for doing so are higher. It will take time for challengers to build additional capacity and overcome established relationships and brand recognition but firms may be more willing to incur these costs if they will gain a larger share of a larger market.

Perhaps most intriguingly, churn is lower in industries with higher markups, with significant negative associations observed in five of the six specifications. The impact of markup on churn remains significant even when controlling for industry and year fixed effects and is evident in both the one-year and three-year time frames. This finding warrants further investigation but one possible explanation is that higher average markups disproportionately benefit the largest firms, reflecting their enhanced market power. Consequently, these larger firms can leverage their market power to solidify their dominant positions, leading to reduced churn among the top firms. More simply, if markups are an indicator of market power, it is perhaps unsurprising that industry in which firms have greater market power, have lower rates of churn.

AMSI, RMSI and Churn Comparison

As a robustness check, we examine how these keys variables also relate to AMSI and RMSI, which we calculate among the top 10 largest firms in each market. We use both the fixed-effects and random-effects estimation techniques here to maintain consistency with the literature on market share instability and allow us to compare with the work of Kato and Honjo 2006. The findings for AMSI are inconclusive; however, we observe that higher import penetration is associated with increased relative market share instability, which aligns with the findings of

Table 3.4: Top 10 AMSI RMSI and Churn Results

	AMSI		RMSI		$Churn^{10}_{t+1(1)}$		$Churn^{10}_{t+3(3)}$	
	RE	FE	RE	FE	RE	FE	RE	FE
IndMU	-0.0343	-0.119	-0.0102	0.00917	-1.074**	-1.657***	-1.538*	-1.760***
	(0.959)	(0.876)	(0.735)	(0.810)	(0.006)	(0.000)	(0.004)	(0.006)
ImpPen	0.000284	0.0552	0.00265*	0.0200***	-0.467	0.0497	-0.0549	-0.0720
	(993)	(0.685)	(0.080)	(0.002)	(0.831)	(0.307)	(0.148)	(0.264)
CR10	0.288***	0.0476	0.0103***	-0.00142	-0.131***	-0.0888	-0.153***	-0.0951
	(0.000)	(0.609)	(0.000)	(0.757)	(0.000)	(0.229)	(0.002)	(0.329)
DIST10	-0.164	-0.123	-0.00320	-0.0118	-0.892***	-0.628***	-0.979**	-0.820**
	(0.634)	(0.716)	(0.856)	(0.559)	(0.002)	(0.009)	(0.019)	(0.026)
IndADV	0.182	0.162	-0.0184	-0.0236	-0.325**	-0.262	-0.240	-0.0281
	(0.690)	(0.817)	(0.264)	(0.373)	(0.170)	(0.467)	(0.477)	(0.949)
IndR&D	0.0215	0.00775	0.000168	-0.00017	0.0591***	0.0595***	0.0716***	0.0790***
	(0.136)	(0.630)	(0.760)	(0.779)	(0.000)	(0.000)	(0.000)	(0.000)
IndCAPEX	-0.456	-0.927	-0.03195**	-0.0309	-0.520*	-0.709*	-1.093***	-0.865*
	(0.475)	(0.331)	(0.124)	(0.247)	(0.079)	(0.056)	(0.002)	(0.003)
GROWTH	0.0171**	0.0172***	0.000238	0.000282***	0.00713	0.0102***	-0.0145	-0.0203
	(0.015)	(0.001)	(0.505)	(0.005)	(0.272)	(0.000)	(0.352)	(0.274)
SIZE	0.110	0.873	0.0177	0.0643*	0.239	0.432	0.667***	0.883*
	(0.804)	(0.323)	(0.221)	(0.091)	(0.377)	(0.186)	(0.000)	(0.087)
cons	5.330	24.97**	5.512***	5.841***	48.98***	45.97***	84.38***	74.99***
	(0.350)	(0.025)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	2371	2371	2359	2359	2141	2141	1616	1616
R-Squared	0.00678	0.00860	0.00522	0.00670	0.0489	0.0505	0.0751	0.0768

All dependent variables pertain to the top 10 firms. The two churn variables, Churn$^{10}t+1(1)$ and Churn$^{10}t+3(3)$, are measured with leads of 1 year and 3 years, respectively, while the explanatory variables are defined for the current year. P-values are indicated in parentheses, with ***, **, and * denoting significance levels at 1%, 5%, and 10%, respectively. The analysis is based on a sample of 255 four-digit markets from 2007 to 2019.

Kato and Honjo 2006. Notably, markups are not significant for either AMSI or RMSI, nor is DIST10, which represents the gap to the next largest firm. We do find some evidence that higher importer penetration is postively associated with RMSI. One explanation of this could be that higher import penetration occurs when markets are more open to international trade and thus greater exposure to the additional risk factors associated with international trade, which are likely to disproportionately affect the largest firms in the market thus influencing RMSI but not necessarily AMSI.

It is important to note that our churn measure complements the two instability measures, as they capture slightly different aspects of competition. High instability, as measured by AMSI and RMSI can indicate either an increase or a decrease in market power among the largest firms. By construction the two measures are indifferent as to whether a firm's market share has increased or decreased. A firm that increases it's market share by 10 percentage points generates just as much absolute and relative instability as one who's share drops by 10 percentage points. In aggregate, AMSI and RMSI consider a market growing more concentrated to be just as stable as one growing less concentrated, therefore high levels of instability could occur as competition weakens as much as when competition strengthens in a market. Our churn measure, however is less ambiguous; in isolation a fall in churn is indicative of weakening competition.

Higher growth rates increase both AMSI and RMSI, which aligns with our results that growth also positively affects churn. But instability is higher in more concentration markets, though not when we control for industry fixed effects. Again the directionality of market share instability using these two measures is ambiguous. The largest firms could be increasing or decreasing their share. Taken together though the results would suggest that the largest firms in concentrated industries see greater fluctuations in their market shares over time but they are less likely to drop out of the top 10. In other words, competition within the top tier is more intense but disruption of those top firms is less likely to occur.

Each metric should of course be evaluated alongside market concentration, as the impact of churn amongst the top x firms diminishes if they control only a small portion of the total market. Nonetheless, our results suggest that higher concentration is associated with greater instability in terms of both RMSI and AMSI, but lower churn. Additionally, we find some evidence that increasing import penetration contributes to relative instability.

3.5.2 Firm-Level Analysis

We now consider for a given firm the probability of sustaining its top tier position for a given number of years. In other words the probability that a firm ranked in the top five by market share survives as a top five firms x years later. We estimate the following equation:

$$\begin{aligned}\text{Sustain}^5(x)_{it} = \beta_0 + \beta_1 \text{Markup}_{it} + \beta_2 \text{TFP}_{it} + \beta_3 \text{Age}_{it} + \beta_4 \text{Capex}_{it} + \beta_5 \text{Sales}_{it} + \beta_6 \text{MShare}_{it} + \\ \beta_7 \text{AdvExp}_{it} + \beta_8 \text{R\&D}_{it} + \beta_9 \text{Empees}_{it} + \beta_{10} \text{Foreign}_{it} + tFE + \epsilon_{it} \end{aligned} \tag{3.5}$$

where $\text{Sustain}^5(x)$ is a dummy variable that equals one if a firm is among the top five largest firms during the current period and remains so x years into the future. We consider this over two time frames: $\text{Sustain}^5(1)$ for one year and $\text{Sustain}^5(3)$ for three years. The coefficients $\beta_0, \beta_1 ... \beta_9$ are to be estimated, with subscripts i and t representing individual firms and years, respectively. The final term, ϵ_{it}, represents the error term.

Markup and TFP refer to firm-level markups and total factor productivity, respectively, estimated using the methodologies outlined by De Loecker and Warzynski 2012 and Levinsohn and Petrin 2003. Capex represents a firm's total expenditure on capital in a given year, while AdvExp indicates total advertising expenses for the same period. R&D is a dummy variable that indicates whether a firm engaged in research and development within that year.

To examine the impact of international trade, we use MShare, which measures the share of imports in a firm's total sales, and Foreign, a dummy variable indicating whether a firm is foreign-owned. Again, we define a foreign firm as one that has an import share exceeding 50 percent and has both immediate and ultimate ownership outside the UK. Additionally, we control for firm age, total sales, and the number of employees, the latter represented by Empees.

Table 3.5 presents the results of estimating Eq. 3.5 using Linear Probability Model (LPM), probit, and logit estimation techniques for both one-year and three-year time frames. Our sample comprises an unbalanced panel of 3,366 firms across 255 industries from 2007 to 2019, each of which achieved a top five ranking by market share in at least one year.

We find evidence suggesting that advertising expenditure provides firms with insulation against churn. Specifically, a £100 million increase in a firm's advertising expenditure is predicted to enhance the probability of sustaining a top market position over three years by roughly 1.1%, and this effect is highly significant.

Table 3.5: Probability of sustainment

	LPM		Logit		Probit	
	$Sust^5(1)$	$Sust^5(3)$	$Sust^5(1)$	$Sust^5(3)$	$Sust^5(1)$	$Sust^5(3)$
Markup	0.000781*	0.000309	0.00213***	0.000720	0.00196***	0.000591
	(0.079)	(0.452)	(0.000)	(0.545)	(0.000)	(0.489)
ITFP	0.0261***	0.0158***	0.0331***	0.00980**	0.0323***	0.0105**
	(0.000)	(0.006)	(0.000)	(0.011)	(0.000)	(0.083)
Age	0.000746	0.00106	0.000555	0.000567	0.000549	0.000588
	(0.361)	(0.174)	(0.405)	(0.099)	(0.464)	(0.184)
FirmCapex	-0.00540***	-0.00419***	-0.00840***	-0.00392**	-0.00765***	-0.00407*
	(0.000)	(0.000)	(0.000)	(0.028)	(0.000)	(0.054)
FirmSales	0.00141***	0.000879***	0.00222**	0.000638*	0.00180***	0.000646*
	(0.001)	(0.001)	(0.013)	(0.024)	(0.004)	(0.031)
FirmMShare	0.00236***	0.00104***	0.00259***	0.000881***	0.00240***	0.000925*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.017)
AdvExp	0.0115**	0.0139***	0.0110*	0.01107*	0.0100*	0.0112*
	(0.023)	(0.006)	(0.071)	(0.025)	(0.092)	(0.048)
RnDer	-0.00642	-0.000744	-0.00418	-0.00253	-0.00546	-0.00278
	(0.576)	(0.946)	(0.700)	(0.705)	(0.608)	(0.696)
Empees	0.0307***	0.0218***	0.0249***	0.0165***	0.0243***	0.0171**
	(0.000)	(0.004)	(0.000)	(0.000)	(0.000)	(0.009)
ForeignFirm	0.0205	0.0404***	0.00749	0.0216***	0.00760	0.0218
	(0.140)	(0.002)	(0.533)	(0.007)	(0.556)	(0.109)
N	10858	8261	10858	8261	10858	8261

All specifications include year dummies. The coefficients for the Logit and Probit models represent marginal effects. P-values are indicated in parentheses, with ***, **, and * denoting significance levels of 1%, 5%, and 10%, respectively. The sample consists of an unbalanced panel of 3,366 firms across 255 four-digit industries, each of which achieved a top five market share in at least one year between 2007 and 2019.

This phenomenon can be explained through the lens of Sutton's theory of endogenous sunk costs (Sutton 1991). Firms invest in higher levels of advertising during initial stages to boost consumer demand for their products in the future, by which point, these initial expenditures become sunk costs. When potential rewards are greater, as seen in larger markets, firms tend to compete more fiercely using these sunk costs, which Sutton then argues this competitive intensity can result in a lower bound of market concentration. Consequently, these endogenous sunk costs increase with market size, thereby preventing further decreases in concentration below a certain threshold. In our estimation firms benefit from this initial outlay as it is predicted to increase their chances of surviving as a top tier firm into the future both over the one year and three year time frames.

Despite these findings, we observe no significant effect for R&D, which is another common example of an endogenous sunk cost. This lack of effect may stem from our binary R&D variable, which only indicates whether a firm engaged in R&D activities in a given year, without providing insights into the extent of those activities. Additionally, we find no significant effect related to the age of a firm.

Conversely, firms with higher sales and a greater number of employees show a higher probability of sustaining their market position over both the one- and three-year time frames, with these effects being significant at least at the 5% level. Interestingly, our results indicate that higher capital expenditure is associated with a decreased probability of sustaining a top-five market share. When controlling for productivity, sales, and the number of employees, this may reflect the consequences of inefficient over-investment in capital or the realisation of risks stemming from incorrect investment decisions in outdated technologies.

Our key variable of interest, markups, suggests firms with greater market power have a better chance at maintain a top end position in the market next year, but we find no evidence that this effect holds over longer time frames. Conversely, firms that are more productive today, have a higher likelihood of sustaining their high ranking next year and three years into the future. One reason this result could occur is that high markups reflect a firm taking advantage of it's market power and reaping excess profits but that this in turn acts as signal to encourage potential entrants or existing competitors to react. However a more productive firm may possess better technological capability that endures as a competitive advantage, with other firms being unable to quickly adopt new production processes that are more efficient or out manoeuvre them by some other means.

We also find firms with higher import shares as a proportion of their total sales demonstrate greater levels of sustainment. Notably, even after controlling for import share, we find some evidence that foreign firms tend to be more persistent than their domestic counterparts over the three year time frame. Firms that sell a large number of imports may be more robust to domestic shocks if their production takes place overseas. There may also exist a degree of product differentiation in the market between imported goods and those produced domestically. In addition to these benefits from importing, foreign firms will likely export to a large number of countries not just the UK and so this diversification might help them with sustaining their dominant position over the longer term. For example, access to multiple markets could allow the foreign importer access to richer consumer data thus allowing them to spot trends and adapt well in advance of the domestic competitors. Foreign firms could also benefit from protectionist subsidies or other governmental support in their home country.

3.6 Conclusions and Discussion

A firm's ability to maintain a dominant position over time is a significant component of its market power. A firm that can charge excessive markups for only one period before being replaced is much less concerning from a competition standpoint than one that can sustain such pricing year after year. In this paper, we define churn as the number of top firms replaced over a given time frame. Our findings indicate that, in a sample of UK markets, churn has decreased among the top five, top 10, and top 25 firms.

We also find evidence suggesting that churn is lower in industries with higher markups and higher levels of concentration, raising concerns about market power in those sectors. Additionally, we present some indication that foreign firms may be more persistent than their domestic counterparts. While we leave a deeper investigation of this phenomenon for future research, it may reflect the relative weakness of smaller domestic firms compared to foreign entities that likely export to multiple economies, including the UK. These foreign firms may be better equipped to withstand market turbulence.

At the firm level markups appear to be correlated with higher levels of persistence as a top tier market share, but this effect is short lived. Meanwhile more productive firms see an enduring advantage that allows them to maintain one of the largest shares in their market.

The UK economy is extremely well integrated into global markets and foreign firms that can

exercise significant market power over larger periods of time must be considered in any analysis of competition in the UK. We show here that such firms appear to be more secure than their domestic competitors and yet are often the ones most easily overlooked by policymakers and academics.

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.1 Markups from production function estimation

.2 Markups from production functions

We estimate markups using the methodology of De Loecker and Warzynski 2012, henceforth DLW. The DLW approach relies on the basic premise that for cost-minimising firms, markups are equal to the wedge between the elasticity of a firm's output with respect to a variable input and that input's share in revenues, assuming the input is set without any adjustment cost. This idea is based on the insights first proposed by Hall 1986, Hall 1988 that markups can be estimated through production function estimation as the difference between marginal cost and price. DLW combine this with the 'proxy approach' to production function estimation (á la Olley and Pakes 1996, Levinsohn and Petrin 2003 and Ackerberg, K. Caves, and Frazer 2015), to estimate markups at the firm level.

We refer readers to the DLW paper for full details but the approach begins with the following production technology for a firm i at time t:

$$Q_{it} = Q_{it}(X_{it}^1, ..., X_{it}^V, K_{it}, \omega_{it}) \tag{6}$$

where X^v represent the V variable inputs used by the firm, such as labour, intermediate inputs, electricity, etc. We also have K_{it}, the capital stock, which is a dynamic input and ω_{it} representing firm productivity as per the proxy approach literature.

Assuming the firm is cost minimising, we can can state the appropriate Lagrangian function:

$$L(X_{it}^1, \ldots, X_{it}^V, K_{it}, \lambda_{it}) = \sum_{\nu=1}^{V} P_{it}^{X^\nu} X_{it}^\nu + r_{it} K_{it} + \lambda_{it} \left(Q_{it} - Q_{it}(\cdot) \right), \tag{7}$$

where $P_{it}^{X^v}$ is the input price of the variable input X^v, and r_{it} is the cost of the capital input. Assuming the variable inputs can be adjusted without cost, the first-order condition with respect to a given variable input is given by

$$\frac{\delta \mathcal{L}_{it}}{\delta X_{it}^v} = P_{it}^{X^v} - \lambda_{it} \frac{\delta Q_{it}(\cdot)}{\delta X_{it}^v} = 0 \tag{8}$$

with the marginal cost of production represented by $\lambda_{it} = \frac{\delta \mathcal{L}_{it}}{\delta Q_{it}}$. From here we can rearrange to

$$\frac{\delta Q_{it}(\cdot)}{\delta X_{it}^v}\frac{X_{it}^v}{\delta Q_{it}} = \frac{1}{\lambda_{it}}\frac{P_{it}^{X^v}X_{it}^v}{Q_{it}} \tag{9}$$

in words, a cost minimising firm's optimal level of a variable input X_{it}^v occurs when it's output elasticity is equal to $\frac{1}{\lambda_{it}}\frac{P_{it}^{X^v}X_{it}^v}{Q_{it}}$. We then define markups as the price-marginal cost fraction, $\mu_{it} \equiv \frac{P_{it}}{\lambda_{it}}$ and substitute $\theta_{it}^X = \frac{\delta Q_{it}(\cdot)}{\delta X_{it}^v}\frac{X_{it}^v}{\delta Q_{it}}$ to represent the output elasticity of an input X. We can now derive the key expression of the DLW approach:

$$\theta_{it}^X = \mu_{it}\frac{P_{it}^X X_{it}}{P_{it}Q_{it}} \quad \rightarrow \quad \mu_{it} = \theta_{it}^X(\alpha_{it}^X)^{-1} \tag{10}$$

where α_{it}^X is the share of firm expenditure on the input X_{it} in total sales, i.e. the value of spending on a given input as a share of total revenue. α_{it}^X can therefore be directly calculated from the data while θ_{it}^X must be estimated. In order to estimate the output elasticities θ_{it}^X, DLW focus on production functions with a scalar Hicks-neutral productivity term and common technology parameters across the set of producers.

.2.1 DLW estimation procedure

The following production function is now estimated

$$y_{it} = f(x_{it}, k_{it}; \beta) + \omega_{it} + \epsilon_{it} \tag{11}$$

x_{it} contains the constant and all variable inputs, and β all the relevant coefficients. DLW test a number of different specification for $f(\cdot)$ with their main results being a 2nd order polynomial where all logged inputs, their squares and full interactions are included. They also discuss the differences between value added specifications of Eq. 11 and gross output specifications.

In estimating Eq. 11, DLW control for unobserved productivity shocks that may be correlated with input choices. These factors represented by ω_{it} are unobserved by the econometrician but realised by the firm in a time frame sufficient for them to act accordingly. One example of a negative shock would be expected downtime of a machine. A firm, realising it will be less productive due to the a machine breakdown, may reduce hours for its staff. The resulting decrease in output would then appear to be solely the result of a drop in L in the data as we cannot observe the downtime of said machine. This will clearly then bias our estimates of the effect of labour in the production function estimation. DLW adopt the proxy approach to

manage this bias and follow Levinsohn and Petrin 2003 via the use of material demand as a proxy.

$$m_{it} = m_t(k_{it}, \omega_{it}, \mathbf{z}_{it}) \tag{12}$$

Eq. 12 is the material demand function used in DLW, where m_{it} is materials and $\mathbf{z}_{it}$ contains additional controls for input demand, such as export status. As in the proxy approach literature they invert the input demand function Eq. 12 and rely on this in the production fucntion estimation i.e. $\omega_{it} = h_t(m_{it}, k_{it}, \mathbf{z}_{it}$. DLW then apply a correction in the manner of ACF to deal with potential collinearity in the input demand function where no parameter is estimated in the first stage. To illustrate the stage of this estiamtion we begin with a value added translog production function.

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + \beta_{ll} l_{it}^2 + \beta_{kk} k_{it}^2 + \beta_{lk} l_{it} k_{it} + \omega_{it} + \epsilon_{it} \tag{13}$$

The first stage then consists of estimating the following

$$y_{it} = \phi_t(l_{it}, k_{it}, m_{it}, \mathbf{z}_{it}) + \epsilon_{it} \tag{14}$$

where

$$\phi_{it} = \beta_l l_{it} + \beta_k k_{it} + \beta_{ll} l_{it}^2 + \beta_{kk} k_{it}^2 + \beta_{lk} l_{it} k_{it} + h_t(m_{it}, k_{it}, \mathbf{z}_{it}) \tag{15}$$

after the first stage we now have an estimate of expected output $\hat{\phi}_{it}$ and ϵ_{it}. As in OP, DLW rely on the following evolution for productivity $\omega_{it} = g_t(\omega_{it-1}) + \zeta_{it}$. The second stage now uses the composite function $\hat{\phi}_{it}$ to identify productivity. For any value of $\beta = (\beta_l, \beta_k, \beta_{ll}, \beta_{kk}, \beta_{lk})$ the productivity term ω_{it} can be estimated as $\omega_{it}(\beta) = \hat{\phi}_{it} - \beta_l l_{it} - \beta_k k_{it} - \beta_{ll} l_{it}^2 - \beta_{kk} k_{it}^2 - \beta_{lk} l_{it} k_{it}$.

Regressing $\omega_{it}(\beta)$ on its lag $\omega_{it-1}(\beta)$ (and any additional controls) DLW then show that innovation to productivity given β, that is $\zeta_{it}(\beta)$ can be recovered, relying on the following moment conditions:

$$E\left(\xi_{it}(\beta)\begin{pmatrix} l_{it-1} \\ k_{it} \\ l_{it-1}^2 \\ k_{it}^2 \\ l_{it-1}k_{it} \end{pmatrix}\right) = 0 \tag{16}$$

DLW then use a we use standard GMM techniques to obtain the estimates of the production function and rely on block boot-strapping for the standard errors. These moments are similar to those presented in ACF.

.2.2 Calculating markups

Continuing with the value-added translog production function, the estimates of $\hat{\beta}$ gained from stage 2 allow use to calculate an estimate for the output elasticity of labour as

$$\hat{\theta}_{it}^{L} = \hat{\beta}_l + 2\hat{\beta}_{ll} l_{it} + \hat{\beta}_{lk} k_{it} \tag{17}$$

we can then incorporate this estimate into Eq. 10. It is worth noting that the expenditure share of a given input is not directly observed since we only know $\tilde{Q}_{it}$, given by $Q_{it} exp(\epsilon_{it})$. Luckily though, stage 1 provides an estimate for ϵ_{it}. Thus we can express the expenditure share as

$$\hat{\alpha}_{it}^{X} = \frac{P_{it}^{X} X_{it}}{P_{it} \frac{\tilde{Q}_{it}}{exp(\hat{\epsilon}_{it})}} \tag{18}$$

this eliminates any variation in the expenditure shares that comes from output variation not correlated with the first stage composite function $\phi_t(l_{it}, k_{it}, m_{it}, z_{it})$ i.e. anything not impacting input demand but that may impact output overall. Markups are then calculated as $\mu_{it} = \hat{\theta}_{it}^{L} (\hat{\alpha}_{it}^{L})^{-1}$ as derived in Eq. 10.

In our procedure we deflate output using deflators provided by the Office of National Statistics (ONS) [7]. These are avaiable at the three and four digit level of some industries but where these are not available, the two digit deflator is used. Capital is deflated using annual estimates of gross fixed capital formation (GFCF, investment) published by the ONS at the two digit level [8]. Materials are deflated to at least the two digit level using the Producer price inflation time series published by the ONS [9].

[7] These can be found here.
[8] Available here.
[9] Information of which can be found here.

.3 Proxy Approach to TFP estimation

.4 The Proxy Approach to Production Function Estimation

The practice of estimating production functions is a complex issue with various approaches proposed in the literature (see Van Beveren 2012 for a discussion of this topic). One popular approach in modern IO is the so called "proxy approach" first proposed by Olley and Pakes 1996 (henceforth OP) and later expanded upon by Levinsohn and Petrin 2003 and Ackerberg, K. Caves, and Frazer 2015 (henceforth LP and ACF respectively). It's use can be found in a number of recent highly influential papers. (see Gutiérrez and Philippon 2017, De Loecker and Warzynski 2012 De Loecker, Pinelopi K Goldberg, et al. 2016, Autor et al. 2020, and De Loecker, Eeckhout, and Unger 2020a).

The proxy approach is a means of dealing with the endogeneity of inputs in production function estimation. Firms may realise productivity shocks with in a timeframe in which they can adapt input decisions.

Certain productivity shocks, unobservable to the econometrician, may be realised by the firm in a manner which allows it to adjust input decisions. In the estimation procedure an econometrician will struggle to distinguish between these unobserved shocks that are realised by the firm, ω, and true random noise, ϵ. An example of one such positive shock could be an improvement in managerial ability. Under new, improved leadership, the firm, knowing its teams will be more productive, may choose to hire more workers. The resulting increase in output would be attributed to the extra workers alone, not the fact each member of the team is more productive. If not accounted for this will lead to a bias our estimated impact of labour. This is the simultaneity issue in that a portion of the error term, ω, is impacting the explanatory variables in our production function. OP's unique contribution was to use a firm's investment decision to proxy for unobserved productivity shocks, ω. This is detailed below but intuitively if a firm experiences a positive shock in ω_{it} then it expects to be more productive in the next period and so it will increase investment to take advantage. We can therefore use investment as a proxy for changes in ω.

OP's methodology also deals with selection bias. Firms with a larger capital stock can expect larger future returns for any given level of ω_{it} therefore they will be more likely to continue operations at lower ω_{it} realisations (OP p.1274). A firm with a greater capital stock, k, is thus more robust to negative productivity shocks and therefore less likely to exit the market,

as such ω is decreasing in k as ω can only be lower when$k$ is higher. This will mean a negative relationship between k and ω and so there is likely to be a downward bias on any OLS estimate of the capital coefficient.

.4.1 Olley & Pakes Setup

To understand the method proposed by OP it is worth discussing the key assumptions in their model. Underlying the OP model is a discrete time model of dynamically optimizing firms. Consider a simple Cobb-Douglas production function

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \omega_{it} + \epsilon_{it} \tag{19}$$

Where y_{it} is the log of output, k_{it} is the log of capital inputs, and l_{it} is the log of labour input, all of which are observed. ϵ_{it} are random production shocks not observed or predicted by the firm while ω_{it} are those unobserved productivity shocks that are observed in time for a firm to adapt. This knowledge of ω_{it} at time t bring us to the first important assumption. The information set I_{it} available to the firm at time t contains the current and all previous values of ω.

OP also assume the productivity term ω_{it} evolves as a first order Markov process, i.e.

$$p(\omega_{it+1}|I_{it}) = p(\omega_{it+1}|\omega_{it}) \tag{20}$$

This distribution is known to all firms and is stochastically increasing in ω_{it}. Importantly this is an economic assumption as well as an econometric one. It supposes a firm's expectations on future productivity ω_{it+1} depend only on ω_{it}, and that a firm with a higher ω_{it} can expected better productivity shocks in the future.

Next are a series of assumptions regarding the timing of input choices. Labour is considered a non-dynamic input. The decision on labour inputs is made in the current period for the current period and does not have an effect on a firm's profit outside of that period. Capital on the other hand is considered a state variable in the sense its value is fixed in a given period, having instead been determined by an investment decision last period adding to the existing stock. This means the choice of capital for the current period was decided last period as it takes a full period for the investment to be ordered and implemented. Firm's accumulate capital from both their existing stock and investment in the previous period according to some function $k(\cdot)$

$$k_{it} = \kappa(k_{it-1}, i_{it-1}) \tag{21}$$

where i_{it} is investment in period $t-1$. This assumption implies the current capital stock of a firm was determined in the previous period as a combination of it's accumulated stock and investment made in the previous period. The justification being that capital assets take time top be ordered, delivered and installed.

The final two assumptions required relate to the firm's investment decision, given by

$$i_{it} = f_t(k_{it}, \omega_{it}) \tag{22}$$

we assume there is only one unobserved firm specific state variable, ω, in the investment equation and that $f_t(k_{it}, \omega_{it})$ is strictly increasing in ω_{it}. These are the *scalar unobservable* and *strict monotonicity* assumptions respectively. These assumptions and those on the evolution of ω_{it} in Eq. 20 mean firms with greater productivity shocks, e.g. higher ω_{it} have a higher expected marginal product of capital in the future and will therefore invest more.

To summarise so far, at the start of each period a firm experiences a productivity shock ω_{it} and decides whether to exit or continue operations. If its draw of ω_{it} is below some cutoff threshold $\bar{\omega}_{it}$ it exits the market, receives a particular payoff value, Ψ and does not return. If it chooses to continue it selects its variable inputs (labor) and investment. These decisions are made based on the information available I_{it} and the subsequent predictions on its future productivity.

Each firm i is assumed to maximize the present discounted value of net cash flows according to

$$V_t(\omega_t, k_t) = \max\left\{\Psi, \sup_{i_t \geq 0}\left[\pi_t(\omega_t, k_t) - c(i_t) + \Delta E[V_{t+1}(\omega_{t+1}, k_{t+1})|I_t]\right]\right\}, \tag{23}$$

where $\pi_t(\cdot)$ is a restricted profit function giving current period profits as a function of the vector of state variables, $c(i_t)$ is the cost function of current investment, and Δ is the firm's discount factor. In essence, firms make a prediction on their current and future profit levels, based on the value of their state variables ω_{it} and k_{it}, and will continue if this exceeds the exit payoff value Ψ.

.4.2 OP Estimation Stages

Our assumptions around Eq 22 allow us to invert the investment function to state the productivity term ω_{it} as a function of observables.

$$\omega_{it} = f_t^{-1}(k_{it}, i_{it}) \tag{24}$$

which can then be substituted back into our production function. Specifying an exact form for f^{-1} can be complex so OP choose to treat it non-parametrically. This means in the first stage we are unable to identify β_0 or β_k, so these terms are combined into the composite function ϕ which is defined as $\phi_t(k_{it}, i_{it}) = \beta_0 + \beta_k k_{it} + f_t^{-1}(k_{it}, i_{it})$, which is then approximated with a 3rd order polynomial.

The first stage in the OP estimation is then

$$y_{it} = \beta_l l_{it} + \phi_t(k_{it}, i_{it}) + \epsilon_{it} \tag{25}$$

Estimation of Eq 25 then provides us with $\hat{\beta}_l$ and $\hat{\phi}_{it}$, an estimate of the labour coefficient and composite term respectively.

Between the first and second stages, as an intermediate step, OP generate estimates of survival probabilities in order to deal with the selection bias outlined above. In the model a firm will exit the market if it experiences a sufficiently harmful productivity shock as it will be more profitable to receive some sell-off price than to continue operations. If its draw of ω_{it} in period t is below the threshold $\bar{\omega}_{it}$, the firm will exit the market. This gives us a survival condition χ_{it} equal to one if a firm will operate in the current period (i.e. $\omega_{it} > \bar{\omega}_{it}$) or zero otherwise. Using this we can define the following

$$p_{it} = Pr\{\chi_{it} = 1\} \tag{26}$$

which is estimated with a 3rd order polynomial series with full interactions of the state variables as regressors in a probit estimation of these survival probabilities.

In the second stage OP exploit the orthogonality of the quasi-fixed capital stock and the current innovation in productivity (Van Biesebroeck 2007 p.543). From the assumptions placed upon the information set available to a firm and the nature of evolutions of ω it is possible to decompose ω_{it} into its conditional expectation at time $t-1$ and a so called "innovation"

component ξ_{it} assumed to be uncorrelated with ω_{it} or k_{it}. Formally

$$\omega_{it} = E(\omega_{it}|I_{it-1}) + \xi_{it} = E(\omega_{it}|\omega_{it-1}) + \xi_{it} = g(\omega_{it-1}) + \xi_{it}. \tag{27}$$

Because this innovation component ξ_{it} may be correlated with the variable inputs, we subtract labour from output and using the estimates of β_0 and ϕ, we can derive an expression with which we can estimate the coefficient on capital.

$$y_{it} - \hat{\beta}_l l_{it} = \beta_k k_{it} + g(\hat{P}_{it-1}, \hat{P}_{it-1} - \beta_k k_{it-1}) + \xi_{it} + \epsilon_{it}. \tag{28}$$

As before, we approximate the unknown function $g(\cdot)$ non-parametrically using a 3rd or 4th order polynomial. In doing so, Eq. 28 will provide the estimated coefficient on the observed state variables (in this case capital).

.4.3 Levinsohn & Petrin Extension

Levinsohn and Petrin 2003 note that using investment as a proxy is problematic as investment is lumpy, i.e. it is common for investment to be zero in a large number of periods. They propose an alternative proxy in the form of intermediate inputs and augment the production function to incorporate intermediate inputs m_{it} (e.g., electricity, materials, etc.) which gives:

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \omega_{it} + \epsilon_{it}. \tag{29}$$

Analogous to the investment function in Eq. 22, LP define an intermediate input demand function as follows (for convenience we use the same function notation):

$$m_{it} = f(k_{it}, \omega_{it}). \tag{30}$$

Importantly, labour does not enter this demand function. The implication here is that both labour and materials are perfectly variable inputs, chosen simultaneously at the time production takes place (Ackerberg, K. Caves, and Frazer 2015).

Proceeding in a similar manner to OP, LP invert Eq. 30 and substitute into Eq. 29 to restate the production function:

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + f^{-1}(k_{it}, m_{it}) + \epsilon_{it}. \tag{31}$$

Again, the unknown function $f^{-1}(\cdot)$ is treated non-parametrically, while β_k and now also β_m are not identified due to their collinearity with the non-parametric term. The first stage now consists of estimating the following:

$$y_{it} = \beta_l l_{it} + \phi_t(k_{it}, m_{it}) + \epsilon_{it} \tag{32}$$

where $\phi = \beta_0 + \beta_k k_{it} + \beta_m m_{it} + f^{-1}(k_{it}, m_{it})$ in the same manner as OP. This first stage gives us an estimate of β_l and the composite term, again denoted as ϕ. As noted by Van Beveren 2012, LP do not incorporate the survival probabilities in the second stage as the efficiency gains were small with an unbalanced panel. From here, LP complete the second stage in the same manner as OP.

.4.4 ACF Collinearity Correction

Ackerberg, K. Caves, and Frazer 2015 argue that there remains an issue of collinearity in OP and LP, noting this is particularly problematic in the case of LP. Even if the assumptions above hold, collinearity may affect the estimation of β_l in the first stage as it is not clear that l_{it} will vary independently of the non-parametric function ϕ.

To illustrate this point, consider the determinants of l_{it} and m_{it} in the LP model. Given that both are perfectly-variable, non-dynamic inputs, it seems reasonable to assume that they are decided in similar ways. From LP we know that intermediate input demand is given by Eq. 30, which might suggest labour might be chosen according to

$$l_{it} = f^*(\omega_{it}, k_{it}). \tag{33}$$

While $f(\cdot)$ and $f^*(\cdot)$ will typically be different functions, they depend on the same state variables. ACF note that intuitively this is just saying the choice of both variable inputs at time t depends on the predetermined value of the dynamic input and the current productivity shock. By assumption we have seen that Eq.30 can be inverted to derive an expression of ω_{it}; if we were to substitute this into Eq.33, we would get

$$l_{it} = \tilde{f}^*(f^{-1}(k_{it}, m_{it}), k_{it}) = \tilde{f}(k_{it}, m_{it}). \tag{34}$$

Eq.34 is problematic as it implies β_l is not identified in the first stage. We cannot simulta-

neously estimate a fully non-parametric (time-varying) function and a coefficient for a variable that is also a (time-varying) function of the same variables. As noted in Ackerberg et al. (2007) "under the assumption that l_{it} is a variable input, for it to have the independent variance needed to estimate our first stage equation there must be a variable, say z_{it}, that impacts a firm's choices of labour but does not impact choices of investment at t. This variable must also have some variance that is independent of ω_{it} and k_{it}. If this were not the case, e.g., if $l_{it} = f(\omega_{it}, k_{it})$, then one can show that l_{it} is perfectly collinear with the nonparametric function ϕ, implying that one cannot estimate β_l from that equation." (p.4227)

ACF resolve the potential lack of identification by using a two-step estimation method that does not attempt to identify any production parameters in the first stage. Put simply, their approach uses labour inside the composite function in a manner similar to that of capital. In the first stage of the ACF correction the following is estimated.

$$y_{it} = \tilde{\phi}_t(k_{it}, l_{it}, i_{it}) + \epsilon_{it} \tag{35}$$

where $\tilde{\phi}_t(k_{it}, l_{it}, i_{it}) = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \omega_{it}$. No coefficients are estimated in the first stage, but we obtain an estimate of the composite term $\tilde{\phi}$ that allows us to isolate and eliminate the portion of output decided by ξ_{it}. The moment condition for the first stage is now

$$E[\epsilon_{it}|I_{it}] = E[y_{it} - \tilde{\phi}_t(k_{it}, l_{it}, m_{it})|I_{it}] = 0. \tag{36}$$

Estimation of the β_l coefficient is now acheived in the second stage along with the other production function parameters in a manner similar to OP and LP. The moment condition for the second stage being

$$\begin{aligned} &E[\xi_{it} + \epsilon_{it}|I_{it-1}] \\ &= E\left[y_{it} - \beta_0 - \beta_k k_{it} - \beta_l l_{it} - g\left(\tilde{\phi}_{t-1}(k_{it-1}, l_{it-1}, m_{it-1}) - \beta_0 - \beta_k k_{it-1} - \beta_l l_{it-1}\right)|I_{it-1}\right] = 0, \end{aligned} \tag{37}$$

where $\tilde{\phi}_{t-1}$ is replaced by its estimate from the first stage. The key difference between this and LP is that since $\hat{\Phi}_{t-1}$ now contains the labour term, it also needs to be subtracted out inside the g function.

Chapter 4

Large Firm Entry into a Mixed Market Structure

Abstract: This paper presents a first attempt at empirically investigating the effect of large firm entry into concentrated mixed market structures in the UK. Using a dataset that combines UK PRODCOM, Business Structure Database (BSD), and Trade in Goods (TiG) data, we analyse the effects of sudden entry by a large firm into industries characterised by a small number of large incumbents and a competitive fringe. By employing a staggered difference-in-differences approach across a number of four-digit UK industries, we examine changes in output, product variety, and market share among large and small firms following entry. Our findings suggest that large incumbents respond strategically to new large entrants by increasing output per variety while reducing product range, with little effect on the smaller fringe firms, indicating potential market segmentation. The study also highlights the significant impact of foreign entrants which is potentially due to their larger scale, underscoring the importance of accounting for foreign firms in aggregate studies of competition.

Keywords: Producer Concentration, Seller Concentration, Competition, HHI.
JEL classifiers: International Trade, Industrial Organisation.

4.1 Introduction

As discussed in Chapters 2 and 3, concerns over weakening competition and high levels of concentration have grown in recent years (see for example De Loecker, Eeckhout, and Unger 2020a, Philippon 2019, Autor et al. 2020, Weche and Wambach 2021 OECD 2018, Furman and Orszag 2018, and CMA 2022). But such analyses often lack an accurate accounting of foreign competitors (Carr and S. Davies 2022, Amiti and Heise 2021). This is despite the fact international trade is extremely concentrated (Bernard, Jensen, et al. 2018, Castellani, Serti, and Tomasi 2010, Mayer and Ottaviano 2007, and WTO 2008) and as shown in Chapters 2 and 3 foreign firms play a significant and persistent role in UK markets.

The distribution of firms sizes is often highly skewed (Axtell 2001, with a small number of large firms, who are able to interact strategically with each other, existing alongside a fringe of smaller competitors who have a negligible impact on the market. This *mixed market structure* is particularly prevalent in markets open to international trade as well where multinationals compete against much smaller domestic only firms. But there is a gap between the fields of industrial organisation (IO) and international trade. The traditional oligopoly models which are commonplace within IO are rarely utilised in the study of trade, where monopolistic competition is the dominant theory. But recently a strand of literature has emerged that models mixed market structures and considers how they help use to understand large firms in international trade. This is part of a wider to trend to bring more oligopoly theory into international trade (Head and Spencer 2017, P. J. Neary 2010).

The seminal work of Shimomura and Thisse 2012, describes how a group of large oligopolistic firms would behave in a market also populated by a fringe of monopolistically competitive fringe. This was later expanded upon by Parenti 2018 to incorporate product differentiation and Pan and Hanazono 2018 to study the role of demand substitutability between and within these groups.

In this chapter we present a preliminary empirical investigation into what happens when there is sudden entry by a large firm into a mixed market, to test the hypotheses laid out in the work of Shimomura and Thisse 2012, Parenti 2018 and **pan**. To our knowledge this is the first attempt to apply these mixed market models empirically and we do so via a staggered difference-in-differences analysis for a number of UK four digit markets that experience sudden entry by a large firm. We consider the impact on those large and small incumbents, and whether

the effect differs if the entrant is a foreign firm. Our results, while rudimentary, suggest that it is large incumbents who react most strongly to large firm entry, and that foreign disruptors have a greater impact, if only because they tend to be of greater size.

In the remainder of this chapter 4.2 discusses the evolution of the mixed market literature and the theorised effect of large firm entry. 4.3 presents our data, and 4.4 our empirical estimation procedure. 4.5 contains the results of our analysis before 4.6 concludes.

4.2 Literature Review

In the appropriately named 'Two and a Half Theories of Trade' P. J. Neary 2010 describes how the study of international trade is dominated by two paradigms, the theory of comparative advantage based on perfect competition, and the theory of product differentiation and increasing returns based on monopolistic competition. The study of international trade in a way that utilises oligopoly theory from industrial organisation has received little attention compared to these two approaches. Interestingly as noted by Mrázová and J. P. Neary 2020, while monopolistic competition specifically originated within Industrial Organisation (IO), it is used relatively rarely there yet remains by far the dominant paradigm in international trade.

On the other hand, as highlighted by Carr and S. Davies 2022 a recent string of highly influential IO papers have contained some empirical issues surrounding the incorporation of foreign firms. Thus there is somewhat of a gap between the study of industrial organisation and trade. Head and Spencer 2017 describes the rise and fall of oligopoly models in international trade with an initial wave of interest in the 80s giving rise to two highly influential papers, the reciprocal-dumping model of J. Brander and Krugman 1983 and the analysis of 'strategic' trade through the third-market model (Spencer and J. A. Brander 1983, J. A. Brander and Spencer 1985).

This is despite that fact that international trade appears to be incredibly concentrated (see for example. Bernard, Jensen, et al. 2018, Castellani, Serti, and Tomasi 2010, Mayer and Ottaviano 2007, and WTO 2008). Total exports from a given country can be shaped by just a handful of firms. Freund and Pierola 2015 show among a sample of 32 countries the top firm on average accounts for 14 percent of a country's total (non-oil) exports, and the top five firms account for 30 percent. Bernard, Jensen, et al. 2018, p. 607 detail how these largest firms are not only more productive but are substantially integrated internationally in the sense that they

export more of each product to each market, export more products to each market, export to more markets, import more of each product from each source country, import more products from each source country, and import from more source countries.

A more recent attempt to infuse oligopoly into models of international trade can be found in Parenti 2018 who incorporates strategic firm behaviour via the use of a mixed market structure. We use the term "mixed market structure" to refer to one in which there are two types of firm size, i.e. multiple large oligopolistic firms competing against a fringe of smaller monopolistically competitive firms. One of the first attempts to model a market structure with different firm sizes was the dominant firm model first proposed by Markham 1951 and later developed by Chen 2003, Gort 1963 and Holmes 1996.

Shimomura and Thisse 2012 were the first to model a mixed market in which group of oligopolistic firms compete strategically with each other alongside a monopolisitcally competitive fringe. More specifically they combine the oligopoly model á la Cournot with symmetrically differentiated products (Vives, 1999) and the monopolistic competition model developed by Dixit and Stiglitz (1977), two standard IO models. Within the mixed markets exists an exogenously given number of large firms n, and a mass $M > 0$ of negligible small firms. The size of the fringe, M is endogenous, determined by free entry and exit adjusting to the intensity of competition in the market overall. These large firms behave strategically, internalising their impact on total output in the market, which the smaller firms take as given. In the Shimomura and Thisse 2012 model, entry by another large firm generates two opposing effects. The first, a strategic interaction as in typically oligopoly theory, whereby incumbents are suppressed following entry. The second, a market expansion effect, which occurs as the increase in competition forces the fringe to shrink thus allowing incumbents to increase their output. Shimomura and Thisse predict an unambiguous increase in large firm output as the latter effect dominates the former. Their model indicates entry can lead to lower prices and higher output overall and thus entry by another large firm is pro-competitive.

Parenti 2018 develops the mixed market model further by allowing large firms to be multi-product and considering alternative preference specifications outside of the CES used by Shimomura and Thisse 2012. In the Parenti model, large firms are defined by their ability to sell multiple product varieties (MP) while the fringe comprises only single product firms (SP). All firms face the same marginal cost, and incur a fixed cost, F, in order to operate within the market. Each firm then pays an additional fixed cost, f, per variety. Parenti's work highlights

the free-riding behaviour of the fringe firms. Each large MP firm, in an attempt to avoid cannibalisation within its product range slightly reduces output and increases prices. This relaxes competition in the market as a whole, which in turn benefits the fringe firms. Unlike in Shimomura and Thisse 2012, entry by another large firm now raises the average price, and sees an increase in the total number of varieties sold. In essence, the new large firm displaces a portion of the fringe and, taking into account the consumers love of variety, trades off a smaller output per variety for a greater breadth of varieties. The effect on welfare is now ambiguous. Parenti considers trade between a number of symmetric countries, each with it's own mix of large MP and small SP firms. Under free trade, an increase in the number of trading partners is predicted to decrease prices and increase the number of varieties. But when we have trade frictions that prohibit the smaller SP firms from exporting, trade liberalisation can potentially increase the market power of the large firms, as it is they alone who benefit from cheaper trade.

Pan and Hanazono 2018 also extend the mixed market model to allow for large MP firms but examine the role of demand substitutability within and across the large and small firm groups. In doing so they help shed light on the conditions under which entry by another large firm can increase or decrease welfare. The fringe can increase in size following entry by another large firm if there is complimentary across the two groups' goods. Meanwhile the effect on the prices, range and profits of large incumbents can be positive is the cross group substitutability is much higher than the degree of substitutability within the MP and SP groups.

Erkal and Pan 2022 consider mixed market mergers, in which two of the large MP firms combine. Their models indicates that even when a merger generates high cost synergies, it can reduce consumer welfare. If the MP firms are already more efficient in terms of per-unit marginal cost of production and the per variety fixed cost, then a profitable merger which fixed costs synergies can lead to higher prices and lower per-variety output. The merged firm takes advantage of the lower per-variety cost to sell more varieties, in turn raising it's price per variety to reduce the competitive pressure between them.

Our work here contributes to the literature by providing a first attempt at testing empirically the effect of large firm entry in mixed markets.

4.3 Data

Our primary dataset is the UK's PRODCOM database[1]. The survey presents annual statistics on the value and volume of products manufactured in the UK from a sample of approximately 21,500 businesses across a range of UK Standard Industrial Classification (SIC) industries, our PRODCOM data covers 221 four digit industries from 2007 to 2019. We combine this with our seller concentration data from Chapters 2 and 3 which utilise the UK Business Structure Database (BSD) and Trade in Goods (TiG) database. The BSD is a yearly extract of the Inter-Departmental Business Register (IDBR), created to provide a panel of UK firms over time. It covers any firm registered for VAT or PAYE purposes, covering 87 percent of UK employees and the associated economic activity (Lemma et al. 2023).[2] The Trade in Goods (TiG) database, provides firm-level imports and exports by country of origin/destination and commodity code. This enables us to focus on churn among sellers rather than producers by excluding exports and including imports in our analysis. The TiG data is derived from HMRC's Overseas Trade Statistics (OTS), collected for administrative and tax purposes.[3]

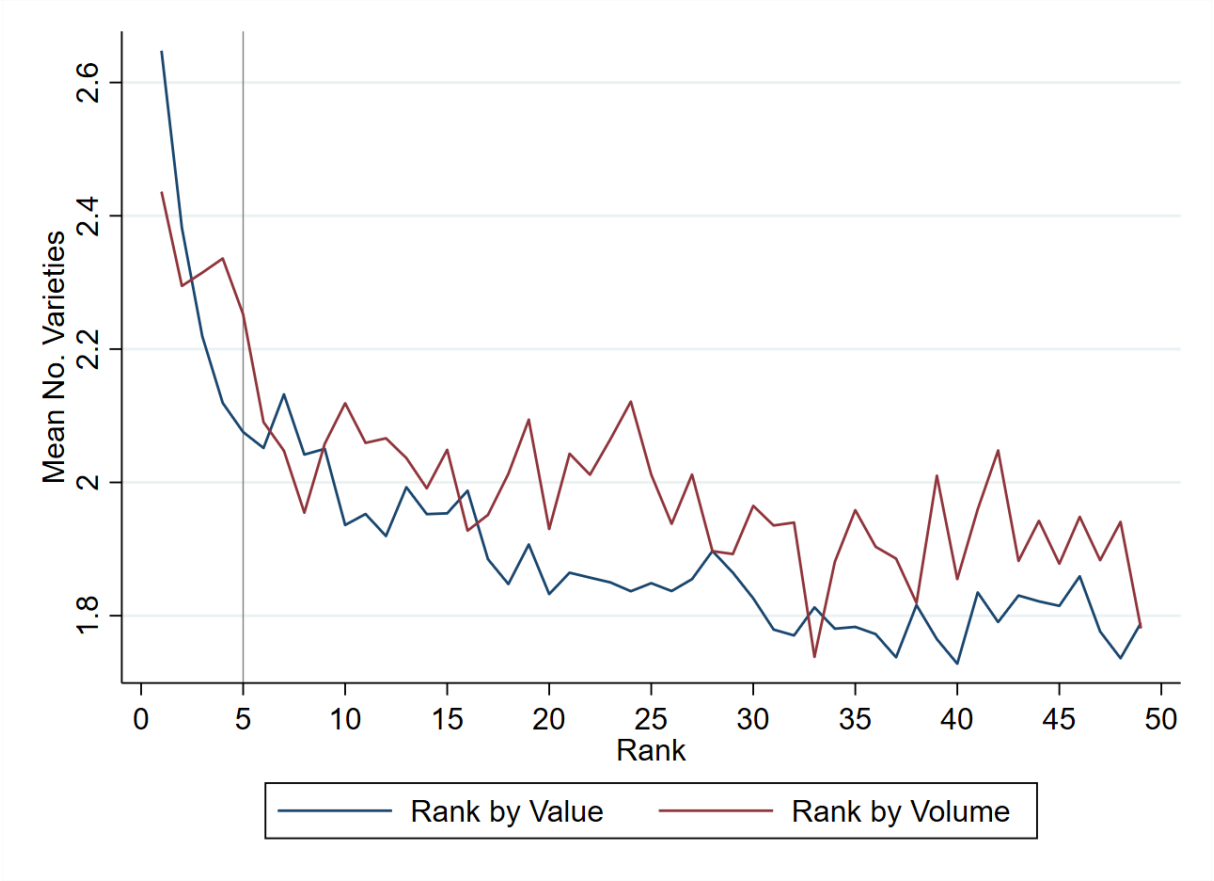
We use the PRODCOM data to study changes in firm output and product range, while the BSD and TiG is used to identify where incidents of large firm entry occur, who the largest incubents are and whether the new entrant is domestic or foreign. In order to test the effect of large firm entry we first to identify suitable markets in the data based on three criteria: high concentration, evidence of large firm entry, and a clear distinction between the large and small firms. We first restrict our attention to markets that would be considered concentrated using traditional anti-trust benchmarks, and so filter out any markets with an average HHI of less than 1000 over the sample period. We do this primarily as unconcentrated markets, by definition, will not contain a small number of large firms. We then try to identify incidents of disruption in which we see a large firm enter the market in a manner similar to those modelled in the mixed market literature. We define an incidence of disruption in a given year t as one in which a firm becomes one of the 5 largest in terms of market share for the first time in that year, remains in the top 5 for at least 3 years, and was not in the market for any of the three years leading up to the disruption event. We choose to use this time frame to smooth out any sampling errors, e.g. a situation in which a firm is top 5 for a single period or misses one reporting year in the data.

[1] More information on the PRODCOM data can be found on the ONS website here

[2] For more information on the BSD, see the Integrated Data Service here.

[3] These datasets were accessed through the UK Office for National Statistics' Secure Research Service and are therefore confidential, limiting our ability to disclose specific industry details to avoid potential identification.

Figure 4.1: Number of varieties sold at each rank



Mean number of varieties sold by X largest firm ranked by total sales value and total sales volume across the sample period 2007 to 2019 for the 19 that meet our mixed market criteria.

The 3 year time frame gives us some confidence that the firm was not in the market leading up to it's entry and that it became a significant player as it remained there for 3 years afterwards. This also helps us to avoid enterprises that may have been assigned to a different SIC in one year. We exclude any double entry events i.e. where two disruptions occur in the same market within 4 years of each other to help isolate the effect of a single large firm entry. Finally we consider the number of varieties sold by firms. In the mixed market models of Shimomura and Thisse 2012, Parenti 2018 and Pan and Hanazono 2018 large and small firms are distinct between groups but symmetric within groups. In reality this is clearly a somewhat unlikely occurrence and firm sizes instead exist at various points along a distribution. However, an examination of the number of varieties sold by each firm can help us to distinguish between the large and the small. In these concentrated markets the top 50 firms control at least 90 percent of all output and so 4.1 displays, for each rank, the average number of varieties sold by a firm at each rank.

There appears to be a break around the 5th largest firm and therefore we segregate large and small firms based on this, quantifying the 5 largest firms in a market as *large incumbents*

Table 4.1: Mixed market variable definitions

Variable Definitions

Variable	Definition
N	Mean number of varieties sold by large incumbents
lQ	Log of average output per variety among large incumbents (volume)
N	Mass of fringe i.e. combined market share of firms that are not large incumbents or the disrupting firm.
lSales	Log of total market sales (volume)
H	HHI calculated on sales volume

Table 4.2: Mixed market variable descriptive statistics

Descriptive statistics

	Mean		**SD**		**Min**		**Max**	
	Disrupted	Non-Disrupted	Disrupted	Non-Disrupted	Disrupted	Non-Disrupted	Disrupted	Non-Disrupted
N	2.18	2.41	1.65	1.60	1	1	9.2	10.6
lQ	13.75	14.09	3.272	3.32	7.94	1.79	19.27	19.25
M	19.81	19.35	14.37	18.82	5.47	0.0	67.69	78.57
lSales	15.73	16.43	3.268	3.58	8.32	3.18	22.04	21.95
H	3744	2938	1690	2072	1013	216	7394	8983

Our sample spans 2007 to 2019 and 212 four digit UK SIC2007 markets, across 24 two-digit sectors. We identify 19 disruption events in our final sample, and split the summary stats above based on which markets were disrupted and which were not. Output and sales are measured in volume, i.e. number of units sold of a given variety.

and all others as the fringe. Combined with our other conditions we identify 19 incidents of disruption in a concentrated market and have the 5 largest firms sells on average 30 percent more varieties than the rest. Table 4.1 defines our key variables and Table 4.2 provides some summary statistics broken down by disrupted markets and non-disrupted.

We use these non-disrupted markets as a counter-factual to those that experience a disruption event as defined above. We find that overall our 19 disrupted markets have higher levels of concentration, slight lower sales by volume of units sold and the largest firms sell marginally fewer varieties on average.

4.4 Empirical Model

To identify the effect of large firm entry in a mixed market we consider 3 key variables. The average number of varieties sold by large firms (N), the average output per variety among large

firms (Q) and the size of the fringe (M).

In the Shimomura and Thisse 2012 model, large firm entry is predicted to shrink the size of the fringe and cause the large incumbents to raise their output. The Parenti 2018 model predicts similar exit for the small firms but the large incumbents are unaffected. Meanwhile the Pan and Hanazono 2018 models argues that while the fringe will shrink, the other large firms might increase their number of varieties and output if there is a sufficiently high degree of substitutability between large and small firm varieties compare to the substitutability within groups.

To investigate the impact of large firm entry we estimate the effect on the three key variables via the following equation:

$$X_{jt} = \beta_0 + \beta_1 \text{Disrupted}_j + \beta_2 \text{After}_t + \beta_3 (\text{T x After})_{jt} + \beta_4 \text{H}_{jt} + \beta_5 \text{lSales}_{jt} + \beta_6 \text{Baseyear}_{jt} + jFE + \epsilon_{jt} \tag{4.1}$$

where X_{jt} represents Q_{jt}, the average output per variety, N_{jt} average number of varieties sold by large firms, and M_{jt} the mass of the fringe, in our 3 estimations. $Disrupted_j$ is a dummy variable equal to 1 if an industry experiences a disruption event as defined above, while $After_t$ is a dummy variable representing the year in which the disruption occurred and three years post. We also control for the level of concentration H_{jt} in HHI for, and market size $lSales_{jt}$ as the log of total market sales, industry fixed effects and the calendar year in which the disruption event occurred $Baseyear_{jt}$. The coefficient β_3, on the interaction between $Disrupted_j$ and $After_t$, therefore provides our predicted impact of the large firm entry disruption event.

We run three staggered Difference-in-Differences estimations on these three variables with comparison groups based on other markets within the same two digit sector. E.g. for the four digit industry represented by UK SIC07 code "10.42 - Manufacture of margarine and similar edible fats" we compare to all other markets that did not see a large firm entry disruption event in the two digit sector "10 - Manufacture of food products". In short, the remaining four digit level markets within each sector are the controls for the disrupted market.

Within each two digit sector we standardise the event time period around the disruption event. E.g. if a large firm enters SIC 10.42 at time t we consider the change in 10.42 seen post entry against what occurred in all the other markets in sector 10 from time t. We retain the calendar year in which the large firm entry occurred as the $Baseyear_{jt}$ and define the pre-disruption period as $t-3$ through $t-1$. The post disruption period, quantified by the After_t

Table 4.3: Difference-in-Differences estimation results

Dependent Variable	N	lQ	M
Disrupted	-6.635***	1.537***	-19.61***
	(0.000)	(0.000)	(0.000)
After	0.0323**	0.0244**	-0.247**
	(0.016)	(0.001)	(0.048)
Disrupted × After	-0.107***	0.0623***	0.383
	(0.007)	(0.004)	(0.302)
lSales	0.0263**	0.984***	-0.927***
	(0.013)	(0.000)	(0.000)
H	-0.000276***	0.0000545***	-0.00211***
	(0.000)	(0.000)	(0.000)
_cons	4.274	-22.92***	175.9**
	(0.566)	(0.000)	(0.012)
IND DUMMIES	YES	YES	YES
BASE YEAR DUMMY	YES	YES	YES
N	4583	4579	4583
R-Squared	0.00693	0.879	0.260

P-values are indicated in parentheses, with ***, **, and * denoting significance levels of 1%, 5%, and 10%, respectively. Sample covers 212 four digit industries, of which 19 experience a disruption event between the years of 2007 and 2019.

dummy is therefore the time from t to $t+3$. This standardisation of the event time is common in the DiD literature (see for example Miller, N. Johnson, and Wherry 2021).

4.5 Results

Table 4.3 presents the results of the estimation of Eq. 4.1 for the 3 dependent variables, N, lQ and M, the mean number of varieties sold by the large incumbents, the mean output per variety among the large incumbents, and the size of the fringe.

The coefficients for $Disrupted \times After$ represent our estimate of the effect of disruption as defined above. We find some evidence that entry by another large firm into a mixed market structure causes the large incumbents to reduce the number of varieties they sell, but increase their average output per variety by about 6 percent.

We find no evidence that the fringe is impacted by the large firm entry this may be because the entrant competes primarily with the large incumbents. These incumbents reduce their range slightly but increase output, attempting to maintain as much market share as possible. Why the fringe is unaffected could reflect potential segmentation with the market. The large and small

Table 4.4: Foreign v domestic disruption

Dependent Variable	N	lQ	M
Disrupted	-6.638***	1.539***	-19.61***
	(0.000)	(0.000)	(0.000)
After	0.0324**	0.0244***	-0.247**
	(0.016)	(0.001)	(0.048)
Disrupted × After (Dom)	-0.0977**	0.0536**	0.385
	(0.017)	(0.017)	(0.314)
Disrupted × After (For)	-0.179**	0.128***	0.365
	(0.034)	(0.006)	(0.644)
IS	0.0267**	0.984***	-0.927***
	(0.012)	(0.000)	(0.000)
H	-0.0000277***	0.0000545***	-0.00211***
	(0.000)	(0.000)	(0.000)
_cons	3.936	-22.63***	175.8**
	(0.597)	(0.000)	(0.012)
IND DUMMIES	YES	YES	YES
BASE YEAR DUMMY	YES	YES	YES
N	4583	4579	4583
R-Squared	0.00714	0.879	0.260

P-values are indicated in parentheses, with ***, **, and * denoting significance levels of 1%, 5%, and 10%, respectively. Sample covers 212 four digit industries, of which 19 experience a disruption event between the years of 2007 and 2019.

firms targeting different consumer groups. It may also be the case that the varieties sold by the fringe firms are sufficiently differentiated so as to not be in direct competition with the large incumbents. A new large firm however, especially one that has grown in another country, may have products with a more mass market appeal and therefore these will conflict more directly with those varieties sold by the existing oligopolistic firms.

We now attempt to distinguish between the impact of disruption from a foreign firm from the impact of disruption from a domestic firm. As discussed in Chapters 2 and 3 the distinction is import as foreign firms will face different competitive pressure, potentially have access to greater resources due to multinational activity, and will likely be of a greater size than a domestic only firm. We continue in the manner of Chapter's 2 and 3 and classify all enterprises that have immediate and ultimate ownership outside of the UK and import more than 50 percent of their total sales are classified as foreign. The variables $Disrupted \times After(Dom)$ and $Disrupted \times After(Dom)$ represent the treatment effects for disruption by a domestic firm and by a foreign firm respectively.

We find that entry by a large foreign firm affects the incumbents in a similar manner to a

large domestic firm entry but to a greater degree. This is likely a reflection of the greater size of these foreign entrants. 9 of the 19 markets which experience disruption have a foreign firm as the entrant. Among those 9, the large foreign firm gains a share of 17.9 percent in it's first yeah, meanwhile among the remaining 10 domestic disruptors average an initial market share of 12.8 percent.

4.6 Conclusion

In this chapter we present an initial empirical investigation into the effects of large firm entry in mixed market structures, focusing on a sample of highly concentrated UK industries. We find some evidence suggesting that entry by another large firm into a mixed market structure affects the existing large firms more strongly than it affects the fringe. Large incumbents tend to increase their output per variety while reducing their product range for a net loss in overall output which is taken up by the entrant, the size of the fringe remaining relatively unaffected. This suggests a strategic reaction from the large incumbents aimed at preserving market share in response to intensified competition from significant new entrants.

Our lack of evidence of the impact on the fringe of smaller firms may indicate a segmented market and lack of substitutability between the varieties sold by large firms and those sold by the fringe. In future work we hope to examine further the conditions necessary for a true mixed market structure where the small firms are directly affected by the strategic interactions of their larger counterparts. We also consider whether entry by a foreign firm differs from domestic entry, and find some indication that the impact on incumbents is stronger, if only because foreign entrants tend to be larger.

We again remind the reader that this piece serves as an early attempt at applying mixed market theory to a number of real world markets. We are only able to identify a few cases where there is rapid entry by a large firm into a mixed market structure, and hope this will encourage others to carry out more in depth investigations.

Mixed markets structures are common, especially in markets open to international trade and understanding how the largest firms in a market interact with each other and how this impacts all others in the market will yield a deeper understanding of real world competitive processes. For policymakers in countries with markets dominated by a small number of foreign giants, understanding how their domestic firms will be affected by their decisions is of greater

importance. Policymakers may wish to monitor and potentially regulate entry dynamics in concentrated markets to ensure that such entries enhance rather than harm overall competition, especially if those largest firms are mainly based outside the home economy.

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Chapter 5

Conclusion & Summary

In this thesis we have attempted to improve the tools that lie at the bedrock of Industrial Organisation. The difference between *seller* and *producer* concentration, the importance of churn, what happens as firms shift in and out of the top positions, these are simple concepts and yet have persisted as gaps in our knowledge due in part to empirical issues in the form of data availability but also some conceptual ambiguity about how best to understand competition and market power. We argue first that studying a market rather the industry, is a more appropriate way to understand competition. Considering only the goods sold within an economy, regardless of where they were produced, is preferable to looking solely at the goods produced in an economy regardless of where they are sold for a number of reasons. Competition Authorities (CAs) will obviously be much more concerned about the impact on consumers within their country. There will exists significant differences between consumers in different countries and each country may have different regulations, barriers to entry, and will have a different set of domestic only firms. We define a simple means of studying concentration in the market, which we term *seller* concentration, provide a means of estimation in the absence of perfect data and then show how our understanding of market conditions changes when firm level data is available thus allowing foreign firms and imports to be incorporated, namely that concentration can be much higher than previously thought, and the largest firms may be overlooked entirely.

We then present a flexible measure of competition as a dynamic process, *churn* and show how, for a sample of UK markets, it suggests competition is weakening. The largest firms in a market are being replaced / removed less and less often. And this has occurred across a range of different firm sizes from the top 5 to the top 25. We find churn to be lower in markets with higher levels of concentration, which taken together suggest these markets are relatively less

competitive. We also consider how our measure is related to other indicators of market power, e.g. markups, and find some evidence that excessive markups can protect a firm's position as one of the largest in it's market. High markups in and of themselves often ring alarm bells for CAs but if the same firms are charging high markups year in year out, then that is a stronger indicator of weak competition. Finally, we attempt a preliminary empirical investigation of mixed market structure theory and how large firm entry can impact incumbents. We find some evidence that foreign firms entering a domestic market compete most intensely with the largest exiting incumbents.

As whole this this piece suggests competition is perhaps weaker than previously thought for a number of UK markets and that it may be weakening further as the largest firms in them grow more stagnant. We highlight the prevalence of foreign firms in UK markets and how their control over large portions of the market likely gives them significant market power enabling them to hold on to large market shares for longer than their domestic rivals.