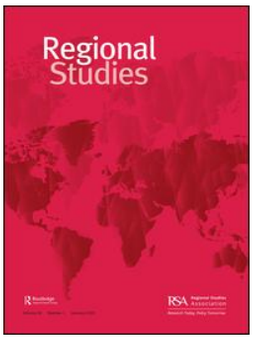

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Place-based public investment in regional infrastructure, the locational choice of firms and regional performance: the case of India

Nicholas Vasilakos[a], Alkis Theonas Pitelis[b], Nick Horsewood[c] and Christos Pitelis[d]

ABSTRACT

We discuss conceptual reasons for and propose public investment in regional infrastructure as a hybrid form of a place-based regional industrial policy aiming to foster the regional economic activity of lagging regions. We present and empirically test a baseline model using data for 14 Indian regions/states over a period of 39 years. Our results show that place-based regional infrastructure investments, particularly in electricity-generating capacity and width-adjusted length of national highways, positively impact the relative number of firms operating in a region and help foster its economic performance.

KEYWORDS

economic activity; public infrastructure; India; spillovers

JEL H54, O25, R11, R12

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1. INTRODUCTION

In recent years we have witnessed the return of industrial and regional policy and strategy following many years of disrepute. Important theoretical contributions include the place-based regional industrial policies, the related Smart Specialisation Strategies (3S) approach and the clusters-ecosystems-based view (Bailey et al., 2018; Pitelis, 2012). These have helped revive, rejuvenate and enrich old debates on the role of markets, firms, governments and geography/place. However, despite significant conceptual and empirical advances, 3S and place-based policies have not been able to demonstrate convincingly a positive impact on regional catching up (Bailey et al., 2020b). In addition, they have paid limited attention to the role of place-based investments in infrastructure and their impact on the choice of location by firms and regional economic activity and performance.

The aim of this paper is to fill these gaps by exploring whether and how a place-based regional infrastructure investment policy can crowd in private investment by helping attract firms and fostering manufacturing output and overall economic activity in lagging regions.[1] To do this, we first provide a bird's-eye view of the debate on industrial policy and strategy and explore the reasons why a targeted infrastructure investment-based policy is likely to be effective. We focus on a key pathway through which this could operate, namely the choice of location and hence the attraction of firms. We then look at the case of India, a fast-developing country that has historically experienced a pattern of uneven growth between regions and which regularly employs infrastructure investments to foster regional growth (Lakshmanan, 2011). Using data for 14 Indian regions/states over a sample period of 39 years, we examine how two key types of hard (tangible) infrastructure, namely electricity-generating capacity and road transport networks (regional and national highways) between states, can affect regional patterns of firm concentration and output.

To guide our empirical analysis, we present a simple theoretical model, described briefly in Appendix A in the supplemental data online and test it. Our empirical

CONTACT Nicholas Vasilakos n.vasilakos@uea.ac.uk
[a] Norwich Business School, University of East Anglia, Norwich, UK
[b] Business School, Neapolis University Pafos, Pafos, Cyprus
[c] Department of Economics, University of Birmingham, Birmingham, UK
[d] Business School, University of Leeds, Leeds, UK

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results are aligned with our theoretical framework and support the argument that a regional infrastructure investment-based strategy can impact the number of firms that operate within a region/state relative to its neighbours and bolster regional performance. We also find support for the argument that the improved provision of infrastructure of a given state can create spillovers and impact industrial activity in neighbouring areas. More specifically, our results show that when the stock of national highways and electricity-generating capacity in a region/state increases relative to its neighbours, there is a significant and positive effect on the relative number of firms that operate in that region/state, as well as on relative output. This provides important policy implications that can help complement those derived from place-based approaches.

Although we are not the first to discuss the importance of investment in public infrastructure as a driver of regional development, our analysis helps to address some important gaps that remain unresolved. First, much of the research on the effect of public infrastructure focuses on data drawn from developed countries – primarily the United States and Europe. As public infrastructure tends to be distributed more unevenly across regions in developing countries (Rose-Ackerman, 2017), it could contribute to the regional disparities often found in large lower middle-income economies (India being a case in point). Our paper addresses this issue by considering regional data on economic performance and public infrastructure from India – a large and rapidly developing economy, which is also characterized by severe regional disparities in the distribution of economic activity (Nayyar, 2008; Singh et al., 2014).

Moreover, the empirical literature tends to focus on the effects of public infrastructure mostly within the region where these investments are placed. In this study, we show that these effects may extend to neighbouring regions: a change in the stock of public infrastructure of an Indian region/state in relation to its neighbours affects relative economic activity between the two region/states. Given that more affluent regions/states are able to use their state budgets to invest more heavily in certain forms of public infrastructure, this finding has important levelling-up policy implications, which will be addressed in this paper.

Specifically, our main contributions are as follows. First, we cross-fertilize the hitherto unconnected literatures on place-based regional strategies and the impact of public investments in regional public infrastructure through their effects on the crowding in of private investment by firms locating in the region. Second, we empirically investigate the effect of investment in public infrastructure in economic activity using data for India, a model case for our purposes in that it is characterized by regional disparities, and it regularly employs public sector regional infrastructure investment policies to help address these. In addition to supporting our main arguments, our results show that different forms of infrastructure have different effects on economic activity between regions/states and that decisions about the allocation of investment between different forms of public infrastructure across regions/states can engender effects that extend beyond the borders of an individual region/state. We also find that the mix of public infrastructure investments matters. For instance, we find that in contrast to national highways and electricity-generating capacity, differences in investment between state highways do not have a significant effect on relative economic activity.

The remainder of the paper is structured as follows. In the next section we briefly review the relevant literature and consider some stylized facts about the distribution of investment in public infrastructure in Indian regions/states. Section 3 provides an overview of our data, summarizes our empirical methodology and presents our results. Section 4 discusses policy implications and presents a policy assessment to showcase the impact of investment in different forms of public infrastructure for lagging regions/states. Finally, section 5 concludes and discusses limitations/opportunities for further research.

2. LITERATURE SURVEY

Our intended contribution in this section is to cross-fertilize two closely related yet until now unconnected areas. First is the literature on industrial policy and regional catching up, with emphasis on place-based and 3S approaches. Second is the role of regional infrastructure investment in crowding in private investment through the choice of location by firms. In this section we first offer a critical bird's-eye view of the said literatures and introduce our country of focus: India.

2.1. Regional industrial policy and the place-based and 3S approach

Following years of disrepute, more recently there has been a renewed interest in the role of industrial policy and strategy in fostering regional and nationwide economic performance (Bailey et al., 2018). The literature on industrial policy has been summarized extensively in several papers and books (e.g., Bailey et al., 2015; Pitelis, 2015), so below we focus on the place-based and Smart Specialisation approaches. This is in part because of their regional focus and in part because of their influence in policymaking, notably at the level of the European Union.

In brief, early approaches to industrial policy can be divided into two broad groups: the neoclassical industry structure-based and the resource and evolutionary-based ones. The former focuses on the efficient allocation of scarce resources through different industry structures, while the latter considers the impact of innovation on resource and value creation (Pitelis, 2015). In the neoclassical model, perfectly competitive industry structures secure optimal resource allocation and the maximization of consumer welfare. Departures from perfect competition undermine this outcome and call for policy intervention to correct structural market failures. The scope for such intervention is limited in that there exist second-best

considerations (turning one but not all industries into perfectly competitive ones cannot guarantee optimal resource allocation), and government intervention is also subject to government failures. These are more pronounced in the case of targeting, namely policies that target to support specific firms or industries. Overall, that suggests caution and minimal state intervention.

The neoclassical model has faced difficulties in explicating the apparent success of targeted industrial policies in Japan and several countries in East Asia (Bailey et al., 2015). The resource and evolutionary perspective help explain this by focusing on the impact of public policy on resource creation and innovation. In this approach, public policy can help create new competitive advantages as opposed to merely relying on extant comparative advantages. This comes about through the systemic effects of public policy that can function as a public entrepreneur (Klein et al., 2010; Mazzucato, 2018) and its linkages to the private sector.

The debate on these matters is ongoing and likely to continue. For our purposes, suffice it to note that it pays attention primarily to value creation at the expense of value capture and underplays the role of location (Bailey et al., 2021). The place-based and Smart Specialisation approaches bear similarities with the resource and evolutionary approach and help address the second problem, namely the lack of locational focus.

In contrast to the earlier location-agnostic approaches, place-based and 3S-type reasoning posit that geography and location matter (Alessandrini et al., 2019; Bailey et al., 2018). Because regions differ in terms of social, cultural and institutional characteristics, policy interventions that build upon extant advantages and stimulate interactions among enterprises, local groups, and policy decision-makers can help them move into new growth trajectories. Instead of targeting sectors and firms as in the 'old-type' industrial policy, 3S can target support to actors in new innovative value-creating activities with commercial potential (Foray, 2015), helping facilitate a process of self-discovery by economic agents (Glückler, 2020; Radosevic, 2017, p. 9). This aligns with views of industrial policy as a 'process of discovery' (Rodrik, 2004). These novel activities can gradually become new region-specific competitive advantages (Bailey et al., 2015; Barca et al., 2012). In this context, economic performance can be bolstered through diversification into more complex, higher value-added activities (Glückler, 2020).

Bailey et al. (2020a) have re-examined extant perspectives and theories on strategic management and regional industrial strategy with an eye to cross-fertilizing the two. Among others, they argued that a successful regional industrial strategy should focus on regional value capture, not just creation and co-creation, and consider the personal interests of regional policymakers and the risks associated with the regulatory capture and the requisite governance structures (Bailey et al., 2020a). Value-capture strategies, such as positioning and identifying, developing and controlling bottleneck assets (assets that are of the essence for any activity), should be essential elements of modern industrial and regional policy (Bailey et al., 2020a). Joint infrastructures and support services (European Commission, 2017), 'open' models of collaboration (Organisation for Economic Co-operation and Development (OECD), 2017), and proximity to all-inclusive support environments and agglomeration effects available in urban centres, alongside regional embeddedness in business ecosystems of open, interconnected networks and strategic partnerships (Bachtler et al., 2017), can help co-create and capture value by and for the region, hence fostering catching up.

Focusing on regional value capture helps address a challenge to conventional place-based policies. By building on extant advantages, such policies can favour those already possessing stronger advantages, potentially exacerbating regional imbalances. Kaldor (1970), who had initiated modern debates on regional policy, had already alluded to such a possibility and employed Myrdal's circular and cumulative causation argument to describe the idea that success can breed success.

Circular and cumulative causation is a broader challenge that also afflicts place-based approaches. For instance, Barro and Sala-i-Martin (1991) raised the question of whether poorer countries or regions would tend to catch up and converge towards richer counterparts. They concluded that despite extant economic theories predicting convergence, empirical studies had raised doubts about the speed of convergence. Their study, which applied a framework to patterns of convergence across 73 regions of Western Europe since 1950, concluded that convergence was very slow . More recently, Barca et al. (2012) examined whether place-neutral versus place-based policies would benefit economic development the most. By looking at both academic and practitioner (notably international organizations) policy thinking, they concluded that a place-neutral development strategy was unlikely to foster catching up by lagging regions and hence that place-based options were needed. Nevertheless, the challenge posed by Kaldor remains and needs to be addressed.

In terms of evidence, Kline and Moretti (2014) developed a spatial equilibrium model designed to characterize the welfare effects of place-based policies on the regional and national economy. They concluded that place-based policies involve potentially severe equity-efficiency tradeoffs and proposed that policymakers should be careful to consider the unintended consequences that can arise from labour and firm mobility (Kline & Moretti, 2014). Glückler (2020) undertook a qualitative (interview-based) analysis of the British region of Coventry and Warwickshire and found 'institutional patterns of short-termism, moderate levels of social capital and an embryonic relational infrastructure to constrain the place-based strategy for industrial diversification' (p. 234). The author concluded that there is a need to shift from 'nodal' to 'linking' policies to support cross-network connections and foster the growth of a regional field for collective action.

Crescenzi et al. (2016) examined the process and conditioning factors that influence the success and failure of

regional interventions that aim to foster cohesion. They employed a dataset comprising 15 beneficiary regions of the European Regional Development Fund over four programming periods (1989–2013) and concluded that there are two key policy design factors in maximizing the achievements of Cohesion Policy: planning consistency, the confluence between planned and realised expenditures, and alignment between regional needs and programme objectives.

Given the above challenges and the comparatively limited funding devoted to place-based interventions, the 3S approach has so far not been able to realise its potential to foster greater regional convergence. More is required to address the challenge and help place-based strategies become more effective (Bailey et al., 2020b; Labory & Bianchi, 2021). Our suggestion in this paper is that certain forms of place-based infrastructure investments that impact the locational choice of firms is a way to do so.

2.2. Public investments in regional infrastructure and the choice of location by firms

The question in this subsection is whether public regional infrastructure investments can help attract firms to the region and boost the regional value capture capacity. If so, that would help complement traditional place-based policies and partly address the challenge of circular and cumulative causation. Drawing upon the model by Dixit and Stiglitz (1977), several studies on the location decisions of firms found that, in general, firms tend to respond to factors related to regional proximity to large consumer markets and suppliers, as well as the cost and quality of factors of production that are available to each region (Fujita et al., 1999). Proximity between firms can be important in fostering mutual learning. Codified knowledge creation is supported by the tacit knowledge aspects of particular activities and is embedded in the region (Maskell & Malmberg, 1999). In this context, it can be argued that regional knowledge spillovers are more likely to be effective if they occur among technologically related industries (Neffke et al., 2011). Additionally, Boschma and Iammarino (2009) have argued that new and related varieties can be transferred into another region through interindustry trade linkages.

On the other hand, several scholars have raised the issue of lock-in for regional ecosystems, and several studies that examined new growth industries in the United States over the 1970s and 1980s concluded that industrial regions could become locked into old and declining industries (e.g., Cooke et al., 1998; Lundvall, 1992; Porter, 1990). Instead, new growth regions could appear to start from scratch when developing new economic activities (Neffke et al., 2011). Lock-ins can undermine regional catching up. A key question in this context is what public policies (if any) can help address this problem.

A pathway through which place-based strategies can contribute to improved economic activity is through public investments in infrastructure that help attract firms to the region. Theories on what drives a firm to choose a specific location can be traced back as early as the late nineteenth century and in particular to Marshall (1890), who argued that local agglomerations could foster economic activity and performance through knowledge spillovers that result from the proximity of similar firms in the same region. These are known as localization or 'specialization' externalities (Marshall, 1890; Van der Panne, 2004). The location decision of a firm often entails comparing the costs and benefits of setting up in one region instead of another (Pitelis, 2012). It can be a cumulative process, with the location decision reinforcing itself through the operation of external economies and spillovers and, in such a way, helping engender spatial concentrations that accentuate regional differences in economic performance and productivity (Kaldor, 1970). Despite the shared legacy and link to agglomeration effects, there has been little by way of linking place-based strategies to investments in regional infrastructure. We seek to address this gap below.

Evidence from the development patterns of several economies suggests that regional differences in economic performance can often be attributed to the uneven allocation of public capital across regions/states (Beeson & Husted, 1989; Chambers et al., 1996; Domazlicky & Weber, 1997). The role of public investment in infrastructure as a determinant of regional economic activity and development has been highlighted in several studies, both in developed and developing countries. For example, using US data, Cook and Munnell (1990) showed that investment in public infrastructure positively affects private sector output, investment and employment at the regional and state levels. Their results have also shown that infrastructure is an important determinant in the decision of firms to locate in US states and that investment in public infrastructure serves as a foundation for growth. Building on these findings, Morrison and Schwartz (1992) and Nadiri and Mamuneas (1991) explored further the link between public infrastructure and performance. They found that public capital reduces private production costs, thus positively affecting productivity.[2]

Pereira and Roca-Sagalés (2003) used data on Spanish regions and showed that the benefit from investment in public infrastructure could be distributed unevenly between regions. Pereira and Roca-Sagalés have shown that the 10 regions in their sample that invested more heavily in public infrastructure managed to boost their economic activity compared with the ones that did not.

The impact of public infrastructure on economic activity can also vary across different sectors and activities. The response of firms to the various types of public infrastructure is heterogeneous, depending on the industry and region they are in. Manufacturing is typically found to benefit from public investment in highways, public buildings, and water and sewer systems (Pereira & Andraz, 2013).[3] It is therefore important for studies that seek to explain the contribution of public infrastructure to economic activity to align the right form of infrastructure provision and policy intervention with the right sector.

The empirical evidence of place-based investment in developing countries is sparse. This is partly because of

the lack of sufficiently rich, disaggregated regional datasets. Jena (2004) estimated the effect of public expenditure on the growth of output for Indian regions/states and found it to be positive and statistically significant. Vijverberg et al. (2011) used Chinese province-level data to estimate the rate of return of public capital in industrial production. They found it to be around 23–25%, whereas they also showed public infrastructure to be a significant determinant of labour productivity for firms in that sector. Elburz et al. (2017) reported transport infrastructure to strongly affect regional output and economic performance in Turkish regions. The importance of roads and highway infrastructure as an influence on output and economic activity is also emphasized in Aakar et al. (2017), who evaluated the effect of four broad types of infrastructure (transport, social infrastructure, communication, and electricity-generating capacity) on the gross domestic product (GDP) of India.

Kambhampati and McCann (2007) employed a rich firm-level cross-sectional dataset and found that agglomeration economies have strong positive effects on the regional performance of Indian manufacturing. Ghani et al. (2011) highlighted differences in educational levels and other forms of public capital across Indian regions/states as a determinant of firm creation.

The extent to which infrastructure investments contribute to regional performance has been equivocal. For instance, Crescenzi and Rodríguez-Pose (2012) concluded that:

> infrastructure endowment is a relatively poor predictor of economic growth and that regional growth in the EU results from a combination of an adequate 'social filter', good innovation capacity, both in the region and in neighbouring areas, and a region's capacity to attract migrants.

Using an unbalanced panel of 180 industries from 1985 to 2007, Fernandes and Sharma (2012) examined the determinants of spatial concentration and entry, within manufacturing, for 16 major Indian regions/states. They concluded that governance, infrastructure and the availability of skilled labour are important determinants of increased concentration and firm entry. They also found that less substitutable inputs, such as roads, increased spatial concentration while more substitutable inputs, such as electricity capacity, did not.

Lall et al. (2001) found a significant concentration of manufacturing firms in large cities, driven in part by the presence of transport infrastructure linking these cities to domestic markets. Moreover, empirical and theoretical research highlights the importance of connectivity (e.g., networks, mobility of human capital) as a determinant of regional performance (McCann & Ortega-Argilés, 2013). This raises the question of whether a more targeted approach to the distribution of public infrastructure across regions (with a particular focus on lagging regions) could foster aggregate growth and development at both the regional as well as national level (McCann & Acs, 2011; Naldi et al., 2020).

2.3. Public infrastructure investments in Indian states/regions

This paper focuses on two critical types of place-based 'hard' infrastructure: road networks (distinguishing between state and national highways) and electricity-generating capacity. Both have been discussed in earlier studies and were deemed important determinants of the long-term performance of manufacturing activity in developed and developing economies.

We start with the availability of a sufficiently developed system of highways (Bougheas et al., 1999; Fernald, 1999; Yao & Zhang, 2001). In India, highways can be broken down into two main categories: national and state highways. Both are region-specific (place-based) forms of infrastructure, but each serves a different role in the road network: national highways are designed to create a road network that links the entire country. On the other hand, state highways are designed to connect the various cities and trade centres within a region/state whilst providing access to the national highways network. They are funded from different budgets and managed by different authorities. According to the National Highways Authority of India Act (1988) (Ministry of Road Transport and Highways, 2012), the responsibility for the management and maintenance of National Highways was passed on to the central government, whereas state highways remained under the authority (and funding of) the Public Works Department of states (Ministry of Road Transport and Highways, 2012). Table 1 provides a breakdown of the various road lengths (km) for the entire country in 2012.

As shown, the total road network of India at the end of the sample period analysed extended to 4,642,797 km, out of which the majority is rural (61.13%) and other Public Works Department (22.02%) roads. National highways constituted only 1.65% of the total length of the road network, 75% of which was equipped with two or fewer traffic lanes. The number of traffic lanes for national highways is often reported as an important factor in the commercial effectiveness of the overall road network. The greater availability of traffic lanes tends to reduce the wait times and transport costs for produce whilst enabling greater mobility for workers (Weisbrod & Beckwith, 1992).

Table 1. Indian road network.

Type of road	Length (km)
National highways	76,818
• Single lane/intermediate lane	16,998
• Double lane	40,720
• Four or more lanes	19,100
State highways	164,360
Other Public Works Department roads	1,022,287
Rural roads	2,838,220
Urban roads	464,294

Source: Ministry of Transport (2012).

From this point of view, a width-adjusted measure of length may be a more appropriate proxy for the road networks' efficiency. The quality of roads is also important and usually is reflected by annual maintenance costs. Given the lack of information on expenditure on highway maintenance, we have adjusted highways for the number of lanes and overall road efficiency by using the width factors proposed by the Indian Ministry of Highways. Table 2 provides an overview of how investment in the three forms of infrastructure has changed for each state over our sample period.

3. METHOD, DATA AND ESTIMATION RESULTS

As already noted, the success of industrial policies in targeting firms and industries has been mixed. This has partly resulted from differences in government selection processes and public sector competencies and capabilities. Arguably, problems related to targeting areas may be less pronounced in the case of lagging regions. Unlike the case of predicting whether a firm or a sector can become winners, identifying and targeting lagging regions seems more straightforward. Moreover, identifying infrastructure gaps is easier, while filling them requires relatively simple public sector capabilities, sometimes little more than adopting a good practice template to select the best contractor to undertake the job.

While this can entail serious implementation problems, not least regulatory capture and corruption, regional policymakers regularly voice their concerns about regional inequities as these link to imbalances in the distribution of public funds. That said, it may also be that lagging regions are poorly performing because they lack other resources and capabilities than merely investments in infrastructure. While we fully acknowledge this, we focus in this section on infrastructure investments relating to the attraction of firms to a region and employ other key factors as controls. The link between public investments in regional infrastructure and the choice of location by firms is not adequately explored in the context of place-based and 3S type industrial policy literature. Investments in infrastructure are, in essence, horizontal policies, albeit in this case applied regionally, hence locationally vertically. Such investments can, in theory, help improve incumbents' performance in the region and help attract new firms and investments.

The remainder of this section explores the link between certain forms of public infrastructure (namely, length of highways and electricity-generating capacity) and regional economic activity whilst considering any spillover effects that may emerge when regional profiles of investment in infrastructure differ significantly between regions. More specifically, we examine how differences in the provision of electricity-generating capacity and road transport networks (state and national highways) between Indian neighbouring regions/states may affect regional patterns of firm concentration and manufacturing output.

We use a baseline Dixit and Stiglitz (1977) type model to guide the quantification of place-based infrastructure in India. This is discussed and explained in some detail in Appendix A in the supplemental data online. Using this model, we derive two reduced-form equations, each of which depicts a different aspect of relative economic activity (number of firms and state output) as a function of relative investment in public infrastructure of a region/state compared with its neighbours (see equations S10 and S11 in Appendix A online).

We then proceed with the econometric estimation, bringing together two main datasets: the industrial series are from the Annual Survey of Industries (ASI).[4] The public infrastructure data are obtained from the Indian Ministry of Road Transport and Highways (2012). Highways are measured by length and adjusted for width to take into account the number of lanes of each highway. Due to the reorganization of states over the 39-year sample period, our empirical estimations have been restricted to data from 14 states.[5]

Table 3 summarizes the main variables used in the empirical analysis, including definitions and descriptive statistics.

Both equations are estimated using panel data, with observations varying over time and across regions/states. The model assumes common elasticities for the relative regional effects for all the variables of interest. The general econometric specification for the relative number of firms (see equation S11 in Appendix A in the supplemental data online) for region/state m relative to its neighbouring states m', takes the form:

$$\begin{aligned}\ln[N^*(m,m')]_t =& \alpha_0 + \alpha_1 \ln[\text{Electricity}^*(m,m')]_{(t-1)} \\ &+ \alpha_2 \ln[\text{NHighways}^*(m,m')]_{(t-1)} \\ &+ \alpha_3 \ln[\text{SHighways}^*(m,m')]_{(t-1)} \\ &+ \alpha Z^*(m,m')_{(t-1)} + \upsilon_m + u_t + \varepsilon_{m,t}\end{aligned} \tag{1}$$

where $Z^*(m, m')_{t-1}$ denotes a vector of non-infrastructure control variables (also expressed in relative terms) that may affect the decision of firms to locate in different regions/states, such as urbanization, labour supply and fixed capital stock. The star operator is used to denote relative values.

The results from the econometric estimation of (1) are presented in Table 4 (specifications 1–5).[6] Specification (1) considers the relative number of firms (N^*) as being determined solely by the relative provision of public physical infrastructure between a region/state m and its neighbours m'. The effect of state highways (*SHIGHWAYS*) is found to be positive but not significantly different from zero. This finding repeats itself in all subsequent estimations, as well as in the estimation of relative output equations, suggesting that the location of firms is not heavily influenced by the availability of state highways. In contrast, the coefficient attached to the width-adjusted length of national highways (*NHIGHWAYS*) ratio is positively signed and statistically robust.

Table 2. Average annual growth rates of Infrastructure.

	Growth of width-adjusted national highways (%)	Growth of width-adjusted state highways (%)	Growth of electricity-generating capacity (%)
Andhra Pradesh	4.52%	4.66%	8.38%
Gujarat	5.79%	2.96%	8.55%
Haryana	5.42%	1.48%	6.48%
Himachal Pradesh	4.13%	0.54%	10.45%
Karnataka	3.94%	4.86%	4.21%
Kerala	2.80%	5.37%	3.97%
Madhya Pradesh	4.24%	2.86%	7.05%
Maharashtra	2.15%	4.08%	6.59%
Odisha	4.59%	2.24%	5.38%
Punjab	3.94%	3.06%	5.43%
Rajasthan	5.54%	5.36%	7.45%
Tamil Nadu	6.42%	7.00%	5.91%
Uttar Pradesh	6.09%	2.21%	4.92%
West Bengal	4.92%	2.39%	4.98%

Sources: Calculated using data from the Ministry of Transport, *Basic Road Statistics of India* (various issues) and Ministry of Power, *Annual Reports*.

This latter finding suggests that firms' spatial decisions are dependent upon the investment in the infrastructure of their region/state, but changes in the provision of infrastructure in other regions/states can encourage movement away from their current location. Indeed, the location of firms is not fixed, and there is some pressure, in the long run, to relocate if neighbouring regions/states offer a better distribution network for goods and inputs into the production process. Moreover, this finding highlights the importance of national highways, as opposed to state highways, for the organized manufacturing sector in India, a finding that is also mentioned in several other studies, such as Ghani et al. (2017) and Chakrabarti et al. (2018).

In Table 4, specifications (2–5) allow for inter-state differences in the labour and capital markets to influence the relative number of firms. The relative number of workers is shown to be a positive and significant determinant in the choice of location. This is unsurprising, given the resource-intensive technological profile of the registered sector (Kesar & Bhattacharya, 2020; Thomas, 2013).

Specifications (2), (4) and (5) show that relative real wages have a negative influence on the relative number of firms located in a particular state and highlight the importance of labour costs as a determinant of the choice of location for Indian firms in the registered manufacturing sector (Dutta et al., 2011). Moreover, it is interesting to note that the electricity-generating capacity is one of the most important determinants that drive the choice of location between regions/states. Indeed, in all the specifications examined in Table 4, the coefficient on the electricity ratio shows up as positively signed and significant, with the highest estimated elasticity out of all three forms of public infrastructure; the impact of the relative width-adjusted length of national highways is a consistently positive and significant effect throughout the specifications. This finding is in line with the persistent electricity deficit exhibited by Indian regions/states over much of the sample period and is aligned with anecdotal references to incidents of power shortages and frequent blackouts affecting the Indian industry, which are often dealt with by firms' private investment in their generating capacity (Allcott et al., 2016; Hulten et al., 2006; Nagaraj, 2008). Since such investments tend to increase the operational costs of firms, manufacturers are inclined to shift their production activities to regions where the public provision of electric power is relatively more reliable.

Specifications (6–8) show the estimation results for equation (2). The general econometric specification used takes the form:

$$\begin{aligned}\ln[Y^*(m,m')]_t = {} & \beta_0 + \beta_1 \ln[Electricity^*(m,m')]_{t-1} \\ & + \beta_2 \ln[NHighways^*(m,m')]_{t-1} \\ & + \beta_3 \ln[SHighways^*(m,m')]_{t-1} \\ & + \beta_4 \ln[N^*(m,m')]_t \\ & + B'Z^*(m,m')_{t-1} + \nu_m + \mu_t + \omega_{m,t}\end{aligned} \tag{2}$$

where, like before, the star operator is used to denote relative values between state m and its neighbours, m'. Again, all explanatory variables have been lagged (thus making them predetermined), with the exception of N^* (number of firms) which has been instrumented.

The number of firms operating in region/state m relative to its neighbours m' is consistently one of the most important determinants of differences in relative state manufacturing output in magnitude and statistical significance.[7] Moreover, infrastructure variables (in their relative terms) are found to be conducive to fostering relative output, suggesting that a larger investment in electricity-generating capacity and national highways in state m relative to m' should be expected to lead to a relatively higher manufacturing output for that state.

Table 3. Variable definitions and summary statistics.

Variable	Definition	Mean	SD
$Firms_{m,t}$	Number of manufacturing firms (factories) in state *m* at time *t*. Annual Survey of Industries	7638.6	5988.8
$Electricity_{m,t}$	Electricity-generating capacity (GW) in state *m* at time *t*. Also in per capita terms (PC). Centre for Monitoring Indian Economy (Energy)	3686	3188
$NHighways_{m,t}$	Width-adjusted length (km) of national highways in state *m* at time *t*. Transport Research Wing, Ministry of Road Transport and Highways; Government of India, Basic Road Statistics of India	4264.1	3264.4
$SHighways_{m,t}$	Width-adjusted length (km) of state highways in state *m* at time *t*. Transport Research Wing, Ministry of Road Transport and Highways; Government of India, Basic Road Statistics of India	9088.8	8436.5
$Fixed\ Capital_{m,t}$	Real capital stock (Rs lakh, constant prices) in state *m* at time *t*, with all Indian price of capital used as deflator. Annual Survey of Industries	28,09507	3,090,604
$Workers_{m,t}$	Number of workers in registered manufacturing in state *m* at time *t*. Annual Survey of Industries	429,629	300,934
$Output_{m,t}$	Real output in registered manufacturing (Rs lakh, constant prices) in state *m* at time *t*. Annual Survey of Industries	5947	8525
$Urban_{m,t}$	Proportion of the state *m* population living in an urban centre at time *t*. Census of India	26.30	9.50
$Agriculture_{m,t}$	Share of agricultural output in state domestic product in state *m* at time *t*. Domestic product of States of India	32.4	11.7

In line with our previous findings, state highways were generally found to have a statistically insignificant impact on the state's relative output – and have therefore been omitted from the reported results. On the contrary, both width-adjusted national highways and electricity generation capacity are found to be highly significant determinants of output. Also, differences in the number of workers are a significant determinant of relative regional performance. This is not surprising as a wider pool of workers is usually highly desirable by manufacturers – and it aligns with results reported by previous studies on the importance of labour supply as a determinant of regional development (Gennaioli et al., 2013; Saxenian, 2005; Trippl & Maier, 2011).

4. POLICY IMPLICATIONS

The key policy implication of our work is that countries and regions could complement horizontal and vertical policies with 'horizontical' policies (Pitelis, 2015), namely policies that are horizontal for a whole region but also vertical in terms of the choice of the region. Related to that observation is that place-based policies should be neither top-down nor purely bottom-up. The principle of subsidiarity and the challenges of regulatory capture suggest that policies are not fully top-down. On the other hand, pure bottom-up approaches can lead to beggar-thy-neighbour policies with regions competing to attract firms, particularly big multinationals with bargaining power. In this process, the incentives offered by competing regions can counterbalance any benefits. The national policy can help mitigate that by targeting really lagging regions, allocating funds on this basis and discouraging destructive inter-regional competition. These support the idea of a 'top-down-bottom-up' approach to industrial and regional strategy (Pitelis, 2015).

Our estimated equations were derived from the theoretical model, with the testable restriction of equal and opposite coefficients imposed on the variables from the neighbouring states. A key policy implication of such a functional form is that additional spending on highways and electricity-generating capacity within a state leads to a higher number of manufacturing firms and/or amount of manufacturing output in that region. The comparative effect can be moderated by neighbouring states undertaking placed-based investments.

Since India has a federal form of government, its road network is overseen by a number of different government authorities. The Ministry of Road Transport and Highways (MoRTH) is responsible for the construction and maintenance of national highways, controlling the speed, connectivity, and pattern of development of this network. MoRTH's vision is 'to achieve enhanced connectivity, quick mobility to a level which accelerates socioeconomic development' (Ministry of Road Transport and Highways, 2022). In this respect, the MoRTH places a limit on Indian states directly competing with each other, thus avoiding beggar-thy-neighbour-type policies.

In a similar way to road transport, the Indian Ministry of Power (MoP) has the responsibility for 'General policy in the electric power sector and issues relating to energy policy and coordination thereof' (Ministry of Power, 2022). Its importance can be seen in a global context as the nation has been responsible for an increase of just

Table 4. Estimation results.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ln(***Firms***$_{m,t}$*)					ln(***Ouput***$_{m,t}$*)		
ln(*Electricity*$_{m,t-1}$*)	0.379***							0.076*
	(0.03)							(0.03)
ln(*ElectricityPC*$_{m,t-1}$*)		0.280***	0.285***	0.282***	0.284***		0.095**	
		(0.03)	(0.03)	(0.03)	(0.03)		(0.03)	
ln(*NHighways*$_{m,t-1}$*)	0.150***	0.105***	0.097***	0.109***	0.108***		0.064*	0.070*
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)		(0.03)	(0.03)
ln(*SHighways*$_{m,t-1}$*)	0.011	0.025	0.020					
	(0.03)	(0.02)	(0.02)					
ln(*Firms*$_{m,t}$*)						0.209***	0.095	0.128*
						(0.05)	(0.05)	(0.05)
ln(*Real Wages*$_{m,t-1}$*)		–0.122**		–0.120**	–0.119**	0.121**		
		(0.04)		(0.04)	(0.04)	(0.04)		
ln(*Fixed Capital*$_{m,t-1}$*)		0.053*	0.046*	0.053*	0.052*	0.288***	0.290***	0.290***
		(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
ln(*Workers*$_{i,t-1}$*)		0.251***	0.257***	0.249***	0.245***	0.523***	0.485***	0.499***
		(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)
ln(*Agriculture*$_{m,t-1}$*)			–0.021		–0.015			
			(0.05)		(0.05)			
ln(*Urban*$_{m,t-1}$*)			–0.050	–0.020	–0.022	0.174*	0.230**	0.258**
			(0.09)	(0.09)	(0.09)	(0.07)	(0.07)	(0.07)
ln(*Population*$_{m,t-1}$*)						–0.186**		–0.220**
						(0.07)		(0.08)
State dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Trend	Trend	Trend
Estimator	GLS	GLS	GLS	GLS	GLS	IV	IV	IV

Table 5. Impact on economic activity from an increase of 10% in place-based infrastructure investment.

	1 Additional firms	2 Additional firms (%)	3 Additional manufacturing output (Rs lakh)	4 Additional manufacturing output (%)
Odisha	107	4%	142	1.97%
Madhya Pradesh	271	4%	308	1.97%
Uttar Pradesh	339	2.4%	246	1.18%
Himanchal Pradesh	75	3%	8	1.48%

under 10% in additional world energy demand since 2000. Over the period 2000–13, there has been close to a doubling of energy demand in India, resulting in the nation's share in global demand increasing from 4.4% to 5.7% in 2013. The government approved the 'Integrated Power Development Scheme' in 2014 to ensure that state utilities provided quality and reliable continuous power supply in the urban areas (Ministry of Power, 2014). Consequently, region/state utilities are encouraged to coordinate electricity supply rather than adopting competitive policies.

The four lagging regions/states, based on manufacturing firms per capita at the end of our sample period, were Odisha, Madhya Pradesh, Uttar Pradesh and Himanchal Pradesh. We can use the estimated coefficients to evaluate the effect of policy interventions in the provision of place-based infrastructure. First, we consider an increase of 10% in all place-based infrastructure investments, with all non-infrastructure variables remaining constant. Given the poor performance of the lagging states, it is assumed that road length increases by the same proportion in each state. As it can be seen from columns 1 and 2 in Table 5, the main effects are felt in Odisha and Uttar Pradesh, both of which benefit by about a 4% increase in the number of factories and just under 2% in output, with the bottom state only experiencing a 3% increase in factories and just over 1% additional manufacturing output.

The second policy simulation considers the required investment in electricity-generating capacity to bring the lagging states up to 60% of the median number of firms in India, with the results given in column 1 in Table 6.[8] The investment in new power stations would be significant as it would require more than doubling of the electricity-generating capacity for the number of firms in the registered sector to meet the target.

Table 6. Electricity-generating capacity required to achieve 60% of the median number of firms and effect on manufacturing output.

	1 Additional electricity-generating capacity (%)	2 Additional manufacturing output (%)
Odisha	39.67%	17.17%
Madhya Pradesh	173.95%	75.30%
Uttar Pradesh	58.60%	25.37%

Similarly, additional investment in width-adjusted road length of national highways has a substantial influence on both measures of economic activity considered in this study. If the place-based investment is combined with policies to subsidize investment in real fixed capital stock, then the overall impact would remove the region/states from the lagging categories. The financial viability of such schemes could be questioned as the cost of building new roads and electricity-generating capacity is unknown, and the above calculations assume that there are no cost differences between regions/states.[9]

Real world case studies of the policy scenarios illustrated in this paper above are provided by the World Bank assistance in the upgrading of roads in India (Kumar et al., 2022; Rajah, 2020). An example of such support is the improvement of sections of the Golden Quadrilateral, a national highway network connecting several major industrial centres, and included transformation of the northern arm of National Highway 2 (Asturias et al., 2019). Policymakers have also concentrated on expanding connectivity in three low-income states, Bihar, Odisha and Rajasthan, in addition to developing the transportation network between regions of two middle-income states, Karnataka and West Bengal (Oxford Policy Management, 2019).

Beyond Indian regions/states, it is widely acknowledged that infrastructure policy is a vital component of any economic programme of developing nations (Crafts, 2009). Basic physical and organizational structures and facilities like roads and electricity grids are the backbones of improved delivery of the private sector and essential public services. According to World Bank data, an overview of developing countries shows a large infrastructure gap exists, with around 1 billion people lacking access to electricity (Bhattacharyya & Palit, 2021). A more detailed examination illustrates that most of the infrastructure deficit lies in the poorest countries in Africa and Asia.

Although the selection of projects varies by country and by industrial sector, there is an urgent need to increase the stock of infrastructure within a country if its development targets are going to be met. Roads are the arteries providing the routes through which the world's economies flow, connecting firms to markets, workers to employment and rural areas to cities. However, in many places in the developing world, especially in Africa, there is a lack of adequate roads. Consider Niger, one of the world's poorest nations, which according to the World Bank had a GDP per capita equal to US$595 in 2021, and the largest part of

its population was under the poverty line (World Bank, 2022). It has a huge infrastructure deficit as less than 20% of the population had access to a road network, whereas only 21% of the roads were paved and classified as primary roads.

Similar considerations apply for electricity-generating capacity. According to UNCTAD (2022), in a quarter of the world's poorest countries more than 75% of the population lack access to electricity. Within these developing countries, electrification in rural areas is particularly low. Even in the urban centres in these nations, around one third of the population does not have access to electricity. For those regions where electricity is available, access is often unreliable and creates problems for firms and households. In the digital age, where individuals, households, and small businesses are linked to financial intermediaries, a reliable source of electricity is essential to provide the tools and opportunities for regions to increase economic activity and get out of poverty.

Investment in transportation remains a key element for development strategies. However, according to our research, simply increasing the width-adjusted length of roads in a region will not necessarily result in any additional activity in the formal sector as the overall outcome depends upon the inter-relationships between regions within a country. There is the possibility of firms relocating to exploit the superior infrastructure in an adjacent region. Consequently, policymakers should consider the network effects of increasing the stock of the basic systems and services in one region within a country, in particular the possibility of bottlenecks developing elsewhere.

The regional policy recommendations should be seen in the context of the cross-country growth literature where increasing inequality appears to be negatively associated with economic development (Berg et al., 2018).

5. CONCLUSIONS

In this paper, we have discussed public infrastructure investment as a place-based industrial strategy and its impact on regional economic activity through its effects on the location of firms. While traditionally industrial policies have been divided as vertical or horizontal, our approach combines the two. Namely, place-based investments in regional infrastructure are horizontal for the region but vertical from the point of view of the choice of location. Despite the obvious connection and its potential impact on regional value capture, the link between place-based strategies, investments in regional infrastructure, and the choice of location of firms has been under-theorised. By helping close this gap, we help advance place-based theory and policy.

To facilitate our discussion, we have developed a baseline theoretical model to explain how differences in the provision of public infrastructure between neighbouring regions can affect the locational decision of firms. We have tested the model by examining the case of India, a fast-developing country which has experienced a pattern of uneven growth between regions/states and which regularly employs infrastructure investments to foster regional growth. Our empirical results suggest that relative differences in state-level infrastructure (investment-based industrial strategy) between neighbouring regions/states are aligned with differences in the relative number of firms and relative output. More specifically, our findings suggest that firms tend to locate in regions/states where infrastructure provision is sufficiently high relative to its neighbouring regions.

Our analysis suggests that out of the three alternative forms of public infrastructure that were considered in this study, electricity-generating capacity and the width-adjusted length of national highways are the two forms of public infrastructure that have the strongest effect, with state highways having a positive but not statistically robust impact on any of the two regional performance measures. A key policy implication of our study is that place-based strategies can be applied in a hybrid way that combines the horizontal character of public investment in infrastructure with the vertical dimension of the regional focus. Focusing on closing gaps in 'hard' infrastructure can help crowd in private investment by attracting firms into the region and fostering economic activity and performance, thus encouraging regional catching up. Such attention is likely to be easier and require lesser capabilities by policymakers than targeting sectors and/or firms, but it can also face implementation challenges, not least related to regulatory capture.

There are some caveats and limitations to our results. First, the baseline model in Appendix A in the supplemental data online is stylized and based on restrictive assumptions. Although this helps us focus our analysis on the key variables of interest, it does not directly capture the effect of many other factors that can influence the decision of a firm to locate between regions. In this context, we have included in our empirical estimations several control variables. Second, the impact of infrastructure on the choice of location in this model is guided by a process that requires neighbouring regions/states to compete against each other to attract new firms, as opposed to a 'network effect' alone. Third, attracting firms, in general, is an important but not the only way to foster regional performance. The type of firms is also an issue, and consideration should be given to whether they are local or multinational. Fourth, there are other types of hard (and soft) infrastructure investments, such as railway networks, as well as improvements in the efficiency of the public sector and the policy making process. These are not considered in our paper and present opportunities for further research.

To conclude, we have explored theoretical reasons and found evidence in favour of the idea that regional convergence can be facilitated by place-based infrastructure investments that help crowd in investments by attracting firms into the region. Identifying and filling such gaps seems easier than targeting firms and sectors, but it still faces implementation challenges. A hybrid, horizontal and vertical/regional policy that also addresses financial and implementation challenges, for instance, by discouraging beggar thy neighbour policies and investing in the capabilities and integrity of decision-makers, can help

foster the ability of place-based and 3S approaches to realise their potential to foster regional performance alongside catching up.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

NOTES

1. A lagging region is defined as a region/state that over our sample period has been characterized by persistently lower rates of growth of GDP relative to the country average. For a detailed discussion of the characteristics of a lagging region (and a stylized definition in the context of the EU), see Crafts (2009).
2. For comprehensive reviews of the literature on the links between public investment in infrastructure and regional development, see Romp and De Haan (2007) and Pereira and Andraz (2013).
3. Pereira and Andraz (2013) also find that although the magnitude of the benefit (which varies across sectors) depends on the type of public infrastructure, there is a long-term complementarity between infrastructure investment and private inputs for nearly all industries in their dataset.
4. The ASI is part of the statistical division of the Indian government. It provides the principal source of industrial statistics and other related technical information in India.
5. Namely, Andhra Pradesh, Gujarat, Haryana, Himanchal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal.
6. Our first set of estimated equations (specifications 1–5) has the number of firms as the dependent variable and seeks to limit endogeneity by taking the first lag of all independent variables. Moreover, our econometric results on relative output have the number of firms as endogenous, and so we use instrumental variables estimation; all other explanatory variables are lagged, making them predetermined.
7. The allocation of new infrastructure investment between states/regions is a political decision, the outcome of which can be influenced by the lobbying activities of companies and/or regions. In this paper, we consider the stock of public infrastructure – rather than new investment in infrastructure, which would be subject more to this source of endogeneity. Although the scope of political economy in explaining the allocation of infrastructure goes beyond the scope of this paper, some literature addresses this question in the context of India, including, for example, Besley and Burgess (2002), Khemani (2010), Dutta et al. (2015) and Coelho and Vijayabaskar (2014). We are grateful to an anonymous referee for highlighting this point.
8. Himanchal Pradesh is dropped from Table 6 as its electricity-generating capacity exceeds the 60% threshold.
9. We thank an anonymous referee for their insightful comments that prompted us to highlight this limitation.

ORCID

Nicholas Vasilakos http://orcid.org/0000-0003-3279-2885
Alkis Theonas Pitelis http://orcid.org/0000-0002-9104-4679
Nick Horsewood http://orcid.org/0000-0001-5081-0368
Christos Pitelis http://orcid.org/0000-0001-9033-6357

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