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Land Transport Infrastructure

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Abstract

Developing economies face particularly challenging decisions on how to distribute limited resources efficiently. A significant proportion of these resources are dedicated to constructing and enhancing infrastructure, with the overarching goals of promoting market integration, spurring long-term productivity, and bolstering the competitiveness of local actors in global markets. This VoxDevLit provides a comprehensive overview of recent policy-relevant findings in the academic literature, specifically focusing on assessing the economic impacts of land transport infrastructure at regional and intracity levels. The survey draws on research using a range of empirical and theoretical methodologies to describe key evidence on the impacts of roads, railroads, metros, and Bus Rapid Transit (BRT) systems in developing countries.

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Summary

Developing countries face significant challenges in providing land transport infrastructure to places and residents. Not only do low and lower-middle-income countries have fewer roads per capita and per square kilometre than high-income countries, but transportation services in many cases are also less reliable and more costly. While this gap suggests that investment in improving the land transportation network may be important for development, evaluating the costs and benefits of land transport infrastructure is crucial for determining whether these investments really deliver higher incomes, and whether the benefits outweigh the costs.

The review discusses how measuring the benefits of land transportation infrastructure must deal with two central challenges, one empirical and one conceptual. Empirically, infrastructure investments are rarely placed randomly, so researchers must utilise modern causal inference methods to separate the effect of infrastructure on a place from the fact that up-and-coming areas may be specifically targeted for investments. Conceptually, concluding whether infrastructure investments lead to actual economic growth is complicated by the fact that infrastructure may displace or relocate economic activity to better connected areas. Recent advances in general equilibrium models that characterise spillovers in other regions can help researchers separate growth from relocation. We view much of the frontier work in this literature as focusing on the effects of infrastructure in the context of missing markets and market failures that are common in developing countries.

The rest of the review discusses results from the academic literature that has looked to answer these questions. We organise the review into two main sections: Interregional transportation and intracity transportation. The interregional transportation literature itself is divided into subsections discussing results from the rail, highways, and rural roads literature. The intracity transportation literature is divided into subsections discussing results from road transit (comprising cars, buses, and BRTs) and rail transit (subways and light rail) literatures. Throughout the review, we try to point out areas where more research is needed.

Our review of the literature finds that highways and trains that connect regions and cities have largely been found to create substantial benefits to connected areas, though larger, relatively more developed, and more industrial cities see larger gains than rural and less developed cities, and factor mobility is crucial for gains to materialise. Compared to interregional highways and rail, rural or last-mile roads on their own have been found to have much more muted impacts on village economies. The evidence is mixed on whether rural roads increase incomes in previously isolated villages, although in the majority of cases they do allow individuals to move out of agriculture.

Urban transit options such as subways and bus rapid transit (BRT) create more value than just travel time saved by bringing residents and firms together, and evidence suggests that they induce less urban sprawl than highways. While urban connectivity promotes formal employment and innovation, the impact of these modes on alleviating congestion or pollutant concentrations associated with car use depends on the context. Recent research applying theoretical frameworks to different developing city contexts suggests that the optimal urban transportation network would be more extensive and involve a larger fleet than existing networks.

1 Introduction

In developing countries, substantial resources are allocated each year to build and upgrade infrastructure, aiming to facilitate market integration, enhance long-term productivity, and improve the competitiveness of local actors in global markets. International organisations support these efforts: The World Bank's portfolio currently includes 165 active transport projects with $33.2 billion in commitments, representing about 10% of total World Bank lending.[1] It is thus vital for academics and policymakers to have a good understanding of the benefits and costs of different transport infrastructure options as well as what aspects to consider in order to maximise expected impacts.

It is in this spirit that this VoxDevLit review provides an overview of recent developments in the academic literature that focus on assessing land infrastructure projects (roads and railways, both between regions and within cities) paying special attention to their effects on economic growth, welfare, and factor reallocation. We build on other surveys of the transportation literature (Redding and Turner 2015, Duranton et al. 2020, Berg et al. 2017), placing specific emphasis on evidence from developing countries and new methods for evaluating the benefits of transportation infrastructure.

In Section 2 of the report, we outline the current landscape of transportation in developing countries, describing quantities and quality of the infrastructure relative to more developed economies. Overall, and not surprisingly, we find an important gap in the quantity and quality of infrastructure. Lower- and middle-income economies only have 25%-33% of the infrastructure of high-income economies in per-capita terms, and even after controlling for the quality and quantity of these gaps, comparisons across locations suggest that transportation costs are still higher. These findings imply significant challenges for developing countries in lowering the cost of transportation along different dimensions, going beyond the provision of more physical infrastructure to improve aspects such as corruption in procurement, bribes paid along highways, and location decisions for infrastructure that follow ethnic or political imperatives rather than economic ones.

Next, in Section 3, we review the different methods and techniques used in the literature to evaluate infrastructure investments. Assessing the impacts of infrastructure projects comes with two significant challenges: i) the issue of endogeneity since infrastructure improvements are not randomly allocated and ii) that investments may generate potential general equilibrium (GE) effects on the overall economy and on unexposed regions. In this context, we examine the approaches used in the literature to tackle these challenges. We particularly focus on techniques that combine difference-in-difference specifications with instrumental variables (IV) and those that use GE models borrowed from the trade literature to understand how infrastructure affects aggregate welfare through trade and commuting linkages using market access measures.

The last two sections review the current literature, organising it into two different categories of infrastructure. **Interregional transportation,** which improves market integration between cities and facilitates trade, and **intracity transportation**, which enhances labour mobility with a focus on improving commuting connections.

Section 4, on the interregional transportation literature, is itself divided into two parts — studies examining the effects of railways, and research focusing on the effects of road infrastructure. Overall, the findings suggest that these investments have had a significant positive effect on the well-being and prosperity of people. However, there are instances in which roads did not generate a significant impact and other cases where governments could have allocated their resources more efficiently. Hence, the evidence highlights the importance of context — the benefits of transportation investments may depend on initial location characteristics such as level of development or sectoral composition. We finish the section describing

1 World Bank Transportation. https://www.worldbank.org/en/topic/transport/overview#2, accessed October 2023.

open questions for future research. For instance, studies of the interaction of these investments with other aspects such as market power in the transportation sector and dynamic effects that involve interactions with climate change and risk.

We proceed with a similar structure in Section 5, reviewing papers that have studied the benefits of intracity transportation in developing country cities. We again divide our literature review into a) road infrastructure (for cars, buses and BRTs) and b) rail infrastructure (subways, light rail and cable car) and summarise the literature that has studied the effect of these different land transportation options on pollution, congestion, and aggregate welfare. As with the case of interregional transportation, there are several open questions, such as the examination of informal transportation modes, the consequences of rapid increases of motorisation in developing countries and the importance of management quality for transit systems.

2 Land transportation landscape in developing countries

2.1 Quantity and quality of infrastructure in developing countries

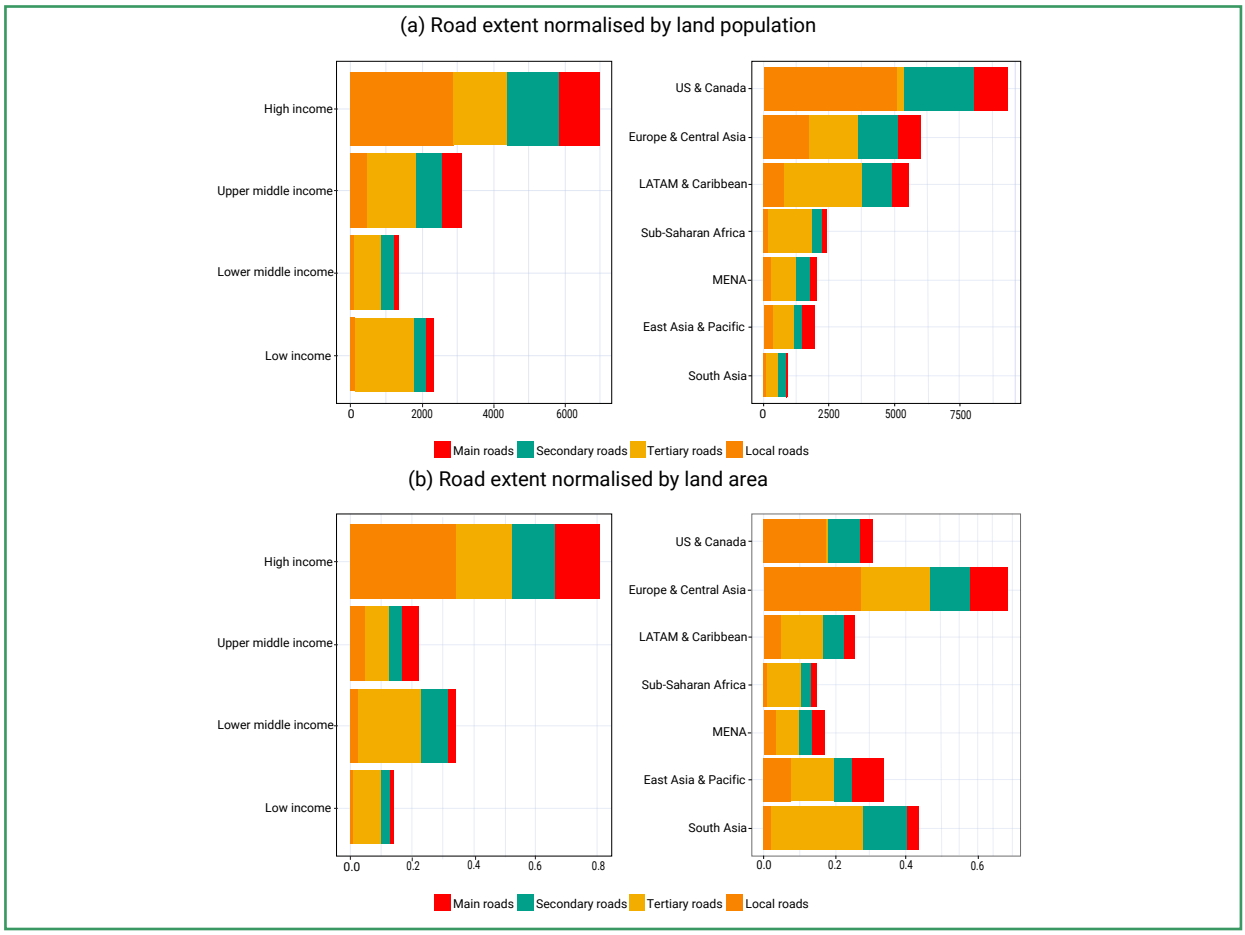
Information on transportation costs is sparse in developing countries, but available measures all suggest that these are very high. Road transport costs per tonne-kilometre in 2007 were 17 US cents in Central America and ranged from 4-13 US cents among countries in Sub-Saharan Africa, compared to 2 cents in the US and 4 cents in France (various sources, reported in Osborne et al. 2014). Inferring transportation costs from spatial dispersion in prices, Atkin and Donaldson (2015) estimate that trade costs increase with distance in Ethiopia and Nigeria at a rate 4-5 times higher than in the United States, and Porteous (2019) estimates that median trade costs in Africa are over five times those in other parts of the world.[2] These differential costs can arise from several sources, including low quantity and quality of physical transport infrastructure as we detail below, but also from less-studied distortions in the economy such as intermediary market power in the transportation sector.

Transport infrastructure is more limited in quantity in developing countries compared with high-income countries. Figure 1 depicts total kilometres of road infrastructure by road type and income group; whether normalising the road extent by population or area, the left panel of Figure 1 shows that high-income countries on average have over twice the density of road kilometres compared to low and lower-middle-income countries. The right panels further compare the average road extents by region, highlighting the deficit faced particularly by countries on the African continent.

Though less information is available about quality than quantity, what we do know suggests that transport infrastructure in developing contexts also lags behind developed countries in quality. For example, only about 13% of the road network in Brazil was paved in 2011 (Mesquita Moriera et al. 2013). Africa again faces steep challenges in infrastructure quality: Foster and Briceno-Garmendia (2010) report that the density of paved roads in Africa in 2008 was only about a quarter of that of other low-income countries. Low quality infrastructure can also impose costs due to its effects on uncertainty about travel time. For example, Iimi et al. (2019) highlight how the unreliability of rail transportation of goods in Ethiopia imposes costs on firms by forcing them to hold inventory when trains are delayed, while Datta (2012) finds that Indian firms hold smaller inventories when connected to the Golden Quadrilateral Highway system. Finally, capacity is an important dimension of quality; Coşar and Demir (2016) study road upgrades from single-lane to multi-lane expressways in Turkey and find that shipment costs are around 70% lower on expressways compared to single-lane roads, and that trade flows respond significantly to road upgrades.

2 For a full review of cost estimation strategies see Coşar (2022).

Figure 1 Road extent



Note: Values represent the population-weighted average across countries of a given income/region of the country's normalised road extent. In panel (a), road extent is normalised by population and has units of kilometres per million inhabitants in 2018. In panel (b), road extent is normalised by the area of the territory and has units of kilometres per square kilometre. In both panels, left figure presents weighted averages by 2022-2023 World Bank income classifications; the right figure presents weighted averages by World Bank region. Road extent information is taken from data compiled by Meijer et al. (2018).

Higher transport costs in developing countries have also been shown to be attributable in part to crime and corruption. In a study on bribes along highways in Indonesia, Olken and Barron (2009) note that on average 15% of the marginal cost of a one-way trip was for illegal payments.

As for urban settings, Akbar et al. (2023b) find that poor country cities have systematically slower within-city travel speeds, and that this is mostly driven by fewer primary roads. Analogously, Akbar et al. (2023a) find that travel times in Indian cities are slow even during uncongested times, and attribute this to lower physical transport infrastructure and the geography of the city.

2.2 Placement and procurement

The literature has identified procurement and placement of infrastructure as key issues that can indirectly contribute to high transport costs in developing countries. Both procurement and placement decisions are complex processes that require strong institutions to function well. Procurement may be manipulated by government officials and firms and corruption can lead to inflated costs or low-quality implementation (Chen 2023). These concerns are present in all forms of government procurement but are especially salient in the case of construction of transportation infrastructure. In deciding where to place infrastructure,

government officials may also have incentives to build roads or provide transit options that are not aligned with social welfare maximisation.

One motivation that can bias the placement of transportation infrastructure is political patronage, in which members of a shared political party or ethnic group bias the provision of services towards members of their group. Burgess et al. (2015) find striking evidence of ethnic favouritism in road development in Kenya; in non-democratic periods, districts that share the same ethnic identity as the president receive over twice as much expenditure on roads as districts with other ethnic groups. Bonfatti et al. (2022) also find evidence that road placement biasing the connection of mining areas to the coast is exacerbated during autocratic periods in West Africa during the post-colonial period, and that part of this bias is driven by ethnic favouritism. Bonilla-Mejía and Morales (2023) find evidence that road development is used as a way to influence the political positions of swing legislators in Colombia, and that road contracts under these conditions are more costly per kilometre than non-sponsored road contracts.

The large resources involved in procurement contracts and the difficulty of monitoring construction quality and maintenance costs, especially in remote areas, can also make infrastructure procurement and operation ripe for corruption and illicit activity. Procurement issues can affect many dimensions of infrastructure, including the cost of procurement, the timeliness of construction, the quality of the final product, its longevity, and the continued operation of the physical infrastructure. While difficult to measure, incidence of corruption in road procurement has been found to be high in different contexts. In cross-country analysis, measures of corruption and conflict have both been found to be strong correlates of the per-kilometre cost of infrastructure (Collier et al. 2016). In a well-known example, Olken (2007) studies village level corruption in road projects in Indonesia and notes that 27.7% of road construction costs reported to the government were never actually spent. Randomly assigning villages to either audits or an intervention designed to increase grassroots community monitoring road projects, he finds that top-down audits are successful at reducing missing costs by 8 percentage points. In India, Lehne et al. (2018) use a close election regression discontinuity design (RD) to study political patronage in roadbuilding contracts, and find that the share of contractors whose name matches that of the winning politician increases from 4% to 7% in the term after a close election compared to the term before. Lewis-Faupel et al. (2016) find that switching to e-procurement, which reduces the scope for corruption in the procurement process, does not lead to cheaper contracts but does result in higher road quality in both India and Indonesia.

2.3 Financing

With much lower levels of government revenue in developing countries as a share of GDP, many have suggested turning to public-private partnerships (PPP) to finance transport infrastructure. While initially these arrangements were proposed as a solution to financing in low state capacity settings, time has shown that these have ultimately played a minor role in financing infrastructure to date. In addition, more research is needed to understand how PPP projects can be structured to deliver the efficiency gains they promise, since the same state capacity issues that motivate PPPs in the first place also present challenges for their implementation (Trebilcock and Rosenstock 2015). Indeed, in their review of the literature on public-private partnerships, Fabre and Straub (2023) conclude that in the case of road procurement, existing evidence suggests that PPPs are more likely to cost more and run over costs than government provision.

Another source of transit infrastructure financing that is getting increased attention is development-based and tax-based land value capture models. While understudied, there are now multiple successful examples of developing country cities using these tools to finance transit investment, operation, and maintenance (Suzuki et al. 2015).

While it is clear that developing countries have less, and more costly, infrastructure, further research is also needed to inform how much investment should go to improving transportation. In the next section,

we outline in broad strokes the frameworks developed by the literature on transportation infrastructure to evaluate the impacts these investments have. Before doing so, it is worth noting that a comprehensive cost-benefit analysis that can help provide policymakers better guidance regarding how much to build and the relative merits of different infrastructure types necessitates reasonable cost estimates. Unfortunately, such costing data are extremely rare, and we note that this generates a gap in the analysis the literature can provide, ultimately focusing on benefits rather than more relevant benefit to cost ratios. In this sense, we highlight that more efforts such as the World Bank (2018) Road Costs Knowledge System on unit costs of road infrastructure in different locations are an extremely valuable source of information to address this gap.

3 Evaluating the effects of transport infrastructure

An immediate impact of new or improved transportation networks is the time saving and/or reduced costs for those using the network, and these impacts were the focus of the traditional approach in economics for evaluating the benefits of transportation investments. In a seminal paper, Fogel (1964) developed a new methodology to evaluate the historical effects of railroads on economic outcomes. In his study, he compares the cost savings from railroads relative to other transportation modes, such as water transport or wagons over land. In a similar approach, McFadden (1974) develops a cost-saving formula to evaluate the benefits of transport infrastructure by calculating average time savings weighted by the value of jobs. While these first approaches incorporate an important benefit of transportation — the implied cost and time savings — into their analysis, the more recent literature on the impacts of infrastructure has focused on confronting two central issues for the identification of causal effects: non-random placement and general equilibrium effects (Redding and Turner 2015).

Infrastructure investments are commonly allocated to places that are more desirable due to either a fundamentally higher productivity for firms or a higher amenity value for consumers. This "non-random" or "endogenous" placement of infrastructure makes it difficult for researchers to disentangle whether infrastructure causes high productivity, or if infrastructure is strategically placed where productivity is already higher or expected to grow. This implies that the use of observational data to estimate impacts will fail to capture the causal effect of investments, because it will be biased by the selection of more productive or attractive places for infrastructure.[3] Instrumental variables are one common approach which has emerged to address the challenge of endogenous placement and obtain causal estimates of the impacts of infrastructure placement.[4]

With this approach, two families of instrumental variables have emerged as predictors of transportation infrastructure placement. The first is historical route instruments (Martincus et al. 2017, Banerjee et al. 2020). The idea behind this approach is that historical roads or railroad routes can predict current infrastructure levels (relevance), and because they are a function of historical determinants, they are not a function of more recent shocks to productivity or amenities conditional on other geographic factors (exogeneity).

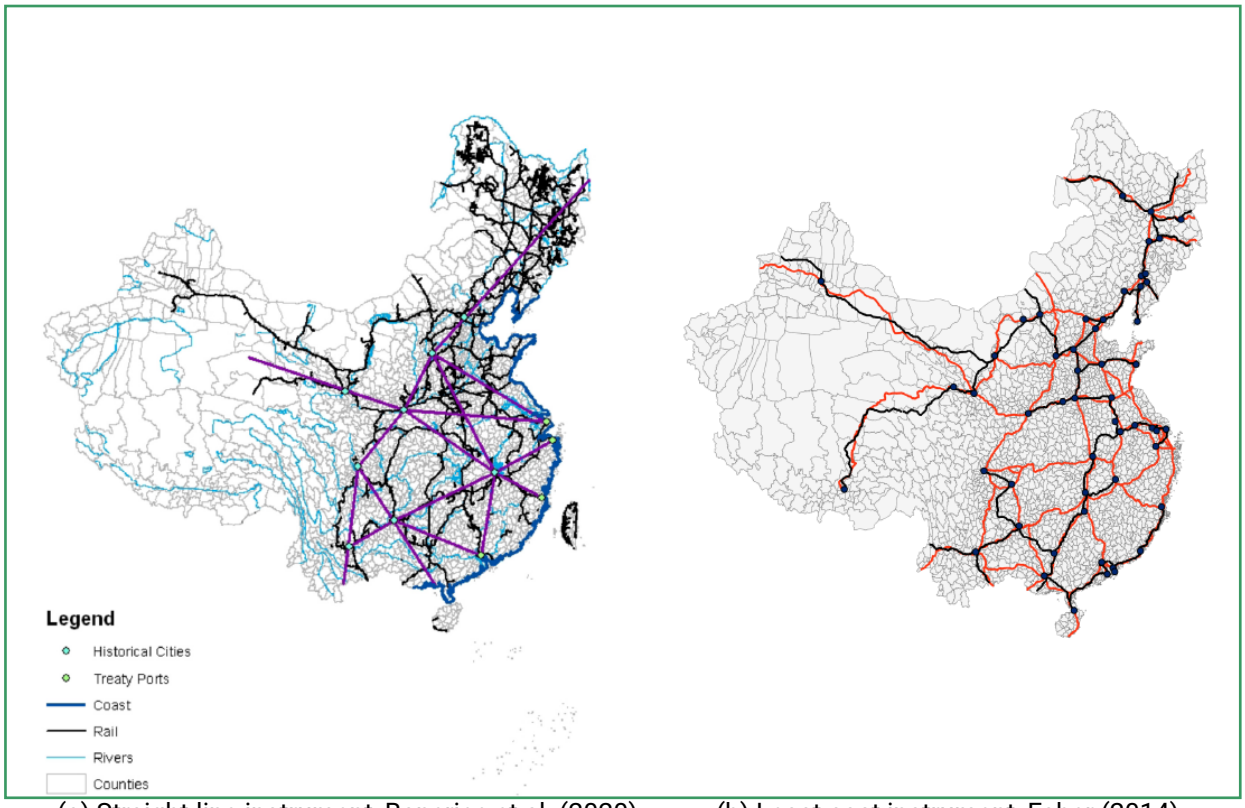
The other popular approach using instrumental variables relies on incidental connections. This strategy argues that the objective of large infrastructure projects is primarily to connect major points of interest — for example two large cities or a large city to a port. In the process of building such a highway or railroad, villages or cities along the way will also be connected, but for these the infrastructure is provided as if by chance (exogenously). Two variants of instruments relying on incidental connections use least cost paths (Faber 2014, Morten and Oliviera 2023, Fenske et al. 2023) or shortest routes (Banerjee et al. 2020, Jedwab

3 It is important to mention that infrastructure allocation can also go in the opposite direction. For example, the allocation of roads for equity concerns can allocate infrastructure to poorer places, leading to an underestimate of benefits (a downward bias in OLS estimates).

4 Randomised control trials are rare in the literature although Gonzalez-Navarro and Quintana-Domeque (2016) is one exception.

and Moradi 2016, Ghani et al. 2016, Garcia-Lopez et al. 2015), as instruments for being connected. Figure 2 provides examples of straight-line and least-cost instruments from Banerjee et al. (2020) and Faber (2014) applied to study highways in the Chinese context. The straight lines drawn in Banerjee et al. (2020) are correlated with the actual road network but are free of political or strategic placement of the true route. In Panel (b), the least-cost instrument in Faber (2014) again approximates the true network but draws the route that would be used to minimise construction costs and should therefore be independent of strategic placement along the way.

Figure 2 Examples of straight-line and least-cost instruments applied to China



(a) Straight-line instrument, Banerjee et al. (2020) (b) Least-cost instrument, Faber (2014)

Note: Both images taken directly from the papers referenced. The instrument in Banerjee et al. (2020) (purple lines) draws a straight line between historically important cities and between historically important cities and the nearest port. The least-cost instrument in Faber (2014) calculates the least-cost path between any two cities by using remotely sensed data on land cover and elevation to characterise costs, and then applying Dijkstra's optimal route algorithm to find the minimum number of connections needed to connect all cities.

These approaches are attractive because they solve the endogenous placement problem. However, they are unable to distinguish between reallocation and growth effects, since part of the difference in outcomes caused by infrastructure could result from diverting activity away from "untreated" to "treated" areas. One empirical strategy to partially address this concern is to assume that such spillover effects are local in nature. Then we can think of two kinds of comparisons: outcomes in areas receiving infrastructure vs nearby areas (which may be affected by reallocation effects), and areas receiving infrastructure vs distant areas (which are not subject to reallocation effects). If these comparisons provide similar estimates, then reallocation effects are likely weak. While these tests are informative about local reallocation effects, this strategy does not deal well with reallocation that is not local in nature, such as when a multinational corporation chooses where to locate a plant amongst multiple distant sites within a country.[5]

5 There are other approaches that the economics literature has employed to solve endogeneity problems when evaluating infrastructure. For example, Asher and Novosad (2020) exploit variation in India from the guidelines by which villages were prioritised to receive new roads based on their population. Also see Casaburi et al. (2013) for a similar strategy in Sierra Leone.

The other challenge that has been confronted by recent advances in the literature refers to better capturing general equilibrium effects. The development of land transportation networks can create large changes in production, prices, commuting, and other outcomes, which implies that the direct effects on time or cost savings are only part of the total gains from these investments. Recent papers have addressed this challenge by building on general equilibrium economic geography models of trade and iceberg transport costs (Allen and Arkolakis 2014, Redding and Rossi-Hansberg 2017, Allen et al. 2020, Allen and Arkolakis 2022). These models incorporate multiple regions and (costly) trade between them, making them well suited to account for indirect effects and to capture overall growth effects, as they consider impacts on both directly and indirectly exposed regions. They also help empirical approaches to aggregate direct and indirect effects, by using models to estimate "market access" measures that capture a location's "access" to trade partners (Donaldson and Hornbeck 2016, Ahlfeldt et al. 2015).[6]

A key advantage of these models is that they explicitly incorporate indirect effects or spillovers and provide a systematic way for thinking about how these impacts interact with market distortions. Distortions and market failures play a significant role in developing countries, and the resource misallocation that they cause means that observed allocations may not be optimal. In this kind of setting, infrastructure can have additional benefits or costs depending on how it interacts with these distortions, and general equilibrium models provide tools for characterising these interactions (Asturias et al. 2019, Balboni 2023, Zarate 2023).

In sum, using general equilibrium models of trade and gravity combined with reduced form estimates and clever causal research designs is increasingly popular and has improved our understanding of the benefits of building infrastructure. These models have allowed researchers to disentangle growth effects from reallocation, and provide a structured — albeit model reliant — way to think about how spillovers behave when locations are connected by trade, migration, or commuting.

In the next sections, we summarise findings from the growing body of research on land transport infrastructure for different modes of interregional transportation and intracity transit.

4 Interregional transportation

Two main types of transportation have been studied in the interregional transportation literature: rail, an important transportation mode that was an especially popular investment during the early twentieth century, and highways, which gained importance in the second half of the twentieth century as motor vehicles became widely available.

Particularly in developing countries, many large rail investments were originally constructed by colonial governments with the motivation of primary resource and agricultural product extraction, and thus these projects tend to connect a productive periphery to a port. This contrasts with highways, which tend to be more recent investments and have more varied purposes, such as connecting major cities to each other or to ports.

4.1 Rail

Both for connecting cities to each other or peripheral areas to major cities or ports, the literature has broadly found that rail has a large long-run positive impact on incomes and economic growth. However, results also suggest that impacts hinge on the ability of factors, i.e. capital and labour, to move in response to changes in the transport network. It is also worth noting that the policy-relevance of these findings for

6 It is relevant to point out recent advances in applied econometrics applicable to the evaluation of infrastructure. In recent work, Borusyak & Hull (2023) propose new methods for estimating causal effects when relying on measures such as market access that rely on exogenous shocks in which exposure to shocks is non-random.

modern times is unclear as these studies are mostly of historic or colonial investments in rail. Empirical tests for spillovers tend to find limited evidence that production is diverted from nearby untreated areas, suggesting that much of the estimated effects are not due to diversion from nearby areas, but rather represent growth effects.

Within the set of papers studying rail lines connecting peripheral areas to a major exporting port or main economic hub are Jedwab and Moradi (2016) and Banerjee et al. (2020), who study the consequences of rail investments in Ghana and China respectively. Both use straight-line paths to instrument for the endogenous placement of railroads, and they both examine the long-run impact of investments from the late 18th to early 19th century period. Jedwab and Moradi (2016) study cocoa production in Ghana and find long run development gains in cocoa areas connected to the coast that persist even after the rail system subsequently collapsed. In contrast, Banerjee et al. (2020) find only a small level effect of rail on the GDP of Chinese cities connected to major cities, and no effect on later GDP growth. One potential explanation for the stark difference between these findings is the fact that labour movement was limited in China during the period of study, highlighting the importance of movement of capital and labour for spurring growth.

In order to empirically test for relocation effects, these studies look for treatment effects in areas that were not directly connected to rail. Jedwab and Moradi (2016) do this by comparing the effect of rail in different bands, e.g. 10-20 km. distance to rail, to further areas, e.g. > 20 km. away. In a similar vein, Banerjee et al. (2020) run their specification excluding the districts nearest to the rail line. Both of these tests are based on the idea that if economic activity is being relocated from nearby areas, then the effect of rail should be negative for these less proximate areas that are losing firms and residents. Neither find evidence that nearby areas are negatively affected by rail development. While in the Chinese context this may be because the policy context did not permit migration or other relocation of factors, the Ghanaian case is puzzling since rail areas did see large increases in both rural and urban populations. Therefore, migration must have come from other areas not nearby rail. This finding highlights the limitation of empirical tests that look for relocation effects in areas nearby treated ones, as relocation may not be limited to nearby places.

Alternatively, some rail systems connect broad areas to each other and are not focused on a connection to a particular port. Studies from the United States have found large gains from 19th century rail investments (Donaldson and Hornbeck 2016, Hornbeck and Rotemberg 2022), and while evidence from developing countries is more sparse, a couple of studies suggest that gains have also been large in India. Donaldson (2018) uses a general equilibrium (Ricardian) model together with a difference-in-difference specification to study railroads in India. From the model, he shows that the own trade share is a sufficient statistic for welfare in this setting and finds that rail spurred large increases in trade between regions and caused an average increase in income of more than 16%. Fenske et al. (2023) construct a least-cost instrument to study the effect of colonial rail expansion on city size in India and find that rail-driven increases in market access significantly increase city size, especially among the initially most isolated cities. In the case of Kenya, Jedwab et al. (2017) study the effect of colonial railroads and find strong evidence of urban path dependence.

Overall, there is less evidence on the impact of intercity high-speed passenger rail on economic outcomes, and we see this as an interesting area for future research. In a recent paper, Tian and Yu (2023) study the impact of the expansion of high-speed rail in China and document increases in export volumes, suggesting that passenger rail may promote firm productivity gains through labour productivity spillovers across locations. Similarly, Barwick et al. (2022) documents that China's rapid expansion of high-speed railways (HSR) facilitates the use of intercity travel as an effective adaptation strategy to climate change since it reduces the exposure to extreme pollution and high temperatures, improving health outcomes.

4.2 Highways

In the case of highways, the empirical evidence on the effect of transportation improvements on incomes is fairly mixed, painting a more nuanced picture than that for rail. While many studies find that highways which connect regions to each other or to major cities or ports have positive welfare effects, the literature has also found that for rural areas connected to major cities specialisation can mean becoming more agricultural and less industrial. The effect of rural or last-mile roads that connect isolated villages to the road network on growth is particularly mixed. Despite the fact that last-mile roads appear to have strong effects on shifting labour out of agriculture in village economies, little impact has been found of roads on income or consumption for those who remain in rural villages.

Studies that focus on highways that connect medium- and large-sized cities to each other have found that these investments have the potential to generate aggregate gains, but also highlight the fact that these gains are not equal across space and may be dampened by poor location choice. For example, Bird et al. (2020), Reed and Trubetskoy (2021), and Lall and Lebrand (2020) use quantitative spatial models to study highway networks in Central Asia. Bird et al. (2020) and Lall and Lebrand (2020) study the potential impact of the Belt and Road Initiative (BRI), a massive infrastructure project that seeks to connect China with the rest of Central Asia and the Middle East. The model-driven approach in Bird et al. (2020) finds that the BRI would increase welfare by 2-3%, and that there is a large amount of heterogeneity in gains between regions. While some would double in size and experience income growth of up to 12%, other areas could see declines, a finding reiterated by Lall and Lebrand (2020), who find that gains concentrate in areas near border crossings. Coşar (2022) studies a series of road capacity upgrades in Turkey using an economic geography model with endogenous labour supply, and finds significant dispersion in welfare gains, with the median gain being 2.9% and a maximum gain of 12.4%. Sotelo (2020) develops a quantitative trade model to study how road paving would affect Peruvian farmers, finding that while gains are heterogeneous, road improvements would lead to a median improvement in farmer welfare of 2.7%, whereas a policy of developing new roads in remote areas would lead to only a 0.2% median gain in welfare. Finally, Fan et al. (2023) use customs data and a spatial equilibrium model to evaluate the benefits of expressway development in China, finding that expressway expansion led to large welfare gains and a 150% return on investment. They highlight how models that ignore general equilibrium effects, the ability of trucks to reroute, and changes in the terms of trade would severely understate the benefits from infrastructure investments.

The economic geography literature has also made progress on the issue of where infrastructure should be placed when future changes to the climate are taken into account. Balboni (2023) extends the economic geography framework to include dynamic impacts and finds that Vietnam's recent coastal bias in infrastructure investments is dynamically inefficient, as future sea level rises imply that land and infrastructure in coastal districts will become submerged. Other biases in infrastructure placement can also dampen its effectiveness. Bonfatti and Poelhekke (2017) find that mines bias land transportation infrastructure and therefore trade in African countries towards overseas exports as opposed to interior trade or trade with neighbouring countries. Finally, Alder (2023) compares India's Golden Quadrilateral, which connects large cities to each other, with China's strategy of connecting intermediate cities. Using a general equilibrium framework, his results suggest that the income-maximising network in India would be larger and benefit initially lower income districts more than the current network.

The evidence for highways that connect peripheral areas to major cities or ports is also mixed, and an important distinction seems to be whether connected cities are primarily engaged in agriculture or manufacturing sectors, as cities tend to specialise as they open to more trade. Some of the existing research that studies highways connecting peripheral regions to major hubs uses instrumental variable approaches (least-cost, straight lines, historic networks) to isolate exogenous variation in exposure to new highways. The findings from this literature run the spectrum from negative growth effects in connected areas to large positive effects. While Ghani et al. (2016) find increases in manufacturing output of around 49% over the decade after construction began in districts connected to the Golden Quadrilateral

connecting Delhi, Mumbai, Chennai and Kolkata, Martincus et al. (2017) finds that highways in Peru that connect regions to the coast increase exports in connected areas by only around 5.6%. Faber (2014) studies peripheral-to-nodal highways in China and finds that local GDP growth, and in particular industrial GDP growth, actually slowed in connected areas.

How can this disparity in findings be explained? One point that distinguishes the context of Faber (2014) from the other studies is that peripheral areas in Faber (2014) were strongly agricultural, and the evidence suggests that being connected to the highway system caused these areas to further specialise in agriculture, whereas the connected municipalities in Ghani et al. (2016) and Martincus et al. (2017) were already manufacturing centres. This suggests that the composition of industry in connected places and the relationship of these areas to the nodal cities they are connected to matter.

Finally, are these growth or relocation effects? Each of these papers design and implement empirical tests for relocation effects by imposing assumptions on the way that spillovers operate and find limited evidence for relocation. Faber (2014) and Ghani et al. (2016) perform proximity-based tests for relocation and find limited evidence that economic activity shifted between nearby districts, but they are not able to test if relocation came from other non-proximate areas. Because Martincus et al. (2017) use transaction-level data with firm identifiers, they are able to implement both a distance-based test and more sophisticated tests for relocation. They compare their main results to estimates that compare connected firms to unconnected firms in different industries and municipalities, with the idea that these estimates should be similar to their main specification if there are no within-municipality or within-sector spillovers. This test slightly relaxes the proximity-based parameterisation of spillovers but is not assumption-free in the form that spillovers take. Jedwab and Storeygard (2022) more flexibly incorporate spillover and relocation effects through an empirical market access approach in studying the impact of transport investments in Africa using roads and cities data spanning 50 years in 39 countries. They build market access measures from population and travel time data to estimate the impact of roads on population and night lights. They find that market access increases population and has a large effect on night lights, and these effects are larger for small and remote cities.

While the above provide suggestive empirical evidence that gains are aggregate and involve more than just a spatial reshuffling of the economy, theoretical frameworks are better equipped to quantify aggregate gains. In this vein, Asturias et al. (2019) study the Golden Quadrilateral project using an economic geography model with variable markups and find that aggregate gains to the manufacturing sector in India are around 2.7%, and that an important share of these gains stem from improvements in allocative efficiency. In another example, Morten and Oliviera (2023) develop a quantitative spatial model with trade frictions in order to estimate the welfare gains from the radial highway network in Brazil. They employ differences in differences and IV strategies and find that areas that were connected to the Brazilian coast via the radial highway network saw increased trade and migration. Through model estimation, they find that the radial highway network increased welfare by 2.8% with the primary channel being goods market integration between cities as opposed to labour market integration. Pellegrina and Sotelo (2023) study how a period of migration west in Brazil, driven in part by road expansion, reshaped Brazil's aggregate and regional comparative advantage. Using a quantitative spatial model, they find that the decrease in migration costs played a pivotal role in altering Brazil's competitive position, leading to its emergence as a prominent exporter of commodities. According to their estimates, the reduction in migration costs accounts for 25% of the observed changes in specialisation. Baldomero-Quintana (2022) finds a similar effect on specialisation studying a major road investment in Colombia.

4.2.1 Rural roads

In theory, roads that connect isolated rural areas to the larger transportation network could promote development through structural transformation, as previously isolated areas can now produce and trade with more industrial areas. While many studies do find sectoral change in response to roads, the evidence that this leads to increased incomes is mixed, and the literature has found that the impact of roads depends on the initial size of the village and the presence of complementary infrastructure. Perhaps because

migration between isolated regions is less of a concern than migration between cities, this literature does not test for spillovers as frequently as the papers studying roads between cities.

Rural areas dominated by agriculture may benefit directly from connectivity if access to more markets and technology increases incomes or productivity, but studies so far suggest that while roads may help moderately developed places grow, they are not sufficient to cause increases in incomes in the most isolated places. For example, Alder et al. (2022) and Mitnik et al. (2018) use night lights data and a difference-in-differences approach to estimate the effect of road improvements on regional growth in Ethiopia and Haiti respectively, and both find that road improvements increase luminosity but only for relatively developed areas whereas the least developed places saw negligible or even negative effects. In India, Asher and Novosad (2020) use a regression discontinuity design based on the rule used to develop roads in different districts to study a policy that provided all-weather feeder roads to unconnected villages, and find no effect of roads on income, assets, or agricultural production. Shamdasani (2021) also studies rural road improvements in India, and finds no effect on agricultural wages, though farm households do increase their use of productivity-enhancing inputs. Gebresilasse (2023) studies the effect of a programme in Ethiopia that connected villages to an all-weather road using a differences-in-differences design and finds that road access led to increased agricultural income only when paired with access to agricultural extension services.

In contrast to these muted empirical findings on the effect of roads on incomes, some studies do find positive effects of roads in rural areas. Gertler et al. (2019) exploit the budgetary allocation process in Indonesia to isolate exogenous variation in highway funding and find that highway improvements led to increases in nominal consumption and income as well as movement of workers from informal to formal employment, implying a 0.45% welfare gain. In their study of river bridges in Nicaragua that reduce uncertainty in market access caused by flooding, Brooks and Donovan (2020) find that farm profits increase by 75% in connected areas, and that connected villages see gains in labour market incomes, particularly outside the village.

Even when roads do not increase incomes, empirical evidence suggests that connecting rural areas to the main road network does lead to shifts of labour out of agriculture and into manufacturing or service sectors. This is the case in Asher and Novosad (2020), who find that despite the null effect on incomes, roads lead to a 9-percentage point shift of workers out of agriculture and into wage labour.[7] Similarly, Shamdasani (2021) finds that roads lead to a 40-percentage point reduction in cultivation, but only in areas that are close to towns. In Ethiopia, Gebresilasse (2023) also finds that villages that do not receive access to extension services see a 22% shift of workers out of agriculture and towards crafts and trade occupations.

4.3 Discussion and open questions

Overall, historic rail investments seem to have large effects on local GDP when factors are able to move. Evidence on highways is more mixed but generally finds positive welfare effects particularly for larger and manufacturing-oriented areas. Though connecting rural areas tends to lead to shifts out of agriculture, whether these shifts lead to gains in income is unclear. However, this body of evidence still leaves important policy questions unanswered. First, do modern investments in railroads deliver the same gains as historic investments? The existing studies are generally limited to colonial rail investments, which were made under very different institutional, economic and political systems than today, and it is unclear whether new rail investments would deliver the same benefits when competing against modern motorised transport options such as trailer trucks. Furthermore, modern interregional passenger rail is relatively unstudied, and we know little about its effect on growth and welfare in developing countries today. For highways and rural roads, what are the factors that influence whether a road will impact economic growth and welfare?

7 The same programme was also shown to increase investments in children's education (Adukia, Asher and Novosad 2020).

We know that the initial size and sectoral composition matter, but how important are determinants of road quality for its ability to drive trade? Finally, how at risk are transportation networks to climate change and natural hazard risk? Balboni (2023) provides an example of how highways in Vietnam are at risk for future sea level rise, but we still know little about how exposed transit infrastructure is to heat, hurricanes, and other natural disasters that will become more frequent with climate change, and what the welfare consequences of these risks will be. There is also a pressing need to learn more about the effects of transportation on environmental impacts. For example, while Asher et al. (2020) show that new rural roads in India had a precisely zero effect on local deforestation, trade models suggest that general equilibrium impacts on deforestation may be large (e.g. Araujo et al. 2023).

5 Intracity transportation

In many ways, the literature on intracity transportation shares the same framework as interregional transportation in that it is important to distinguish between growth effects in economic activity and a reshuffling of economic activity around a city. We point out two key differences. First is the importance of intracity transportation for urban outcomes such as city size, urban sprawl, and labour markets, and second is the fact that intracity transportation infrastructure frequently attempts to address urban externalities like congestion and pollution.

5.1 Road transit: Cars, buses and BRT

Buses and cars share the road in cities, with bus rapid transit (BRT) buses differing from traditional buses in that these have dedicated lanes, allowing them to largely avoid congestion. The physical road network together with the network of public transportation infrastructure and policies like toll roads and High-Occupancy Vehicle (HOV) lanes determine the costs that drivers face, both in terms of direct fees but also in terms of travel times due to congestion, and can even affect the way that cities grow and develop.

5.1.1 Effect of road transportation on city geography and residents

By decreasing commuting costs from peripheral areas, radial or peripheral highways can promote city sprawl and development “out”. While studies from the US, China, and Spain have found that highways promote decentralisation of economic activity (Baum-Snow et al. 2017, Baum-Snow 2020, Garcia-Lopez et al. 2015), whether roads have the same effect on developing cities is less studied, and there are reasons to question whether the same mechanisms would hold in developing contexts. In general, the US model of car commuting from the suburbs may not reproduce itself in developing contexts which have lower rates of motorisation, especially among poorer residents who are frequently drawn to the relatively cheap urban periphery. On the other hand, as rates of motorisation rise in many emerging economies, developing country cities may converge to the commuting patterns observed in more developed ones. Bluhm et al. (2023) provide evidence from Chinese investments in transportation infrastructure in developing countries across the world that within-region economic activity decentralises in response to Chinese investments; given that per-capita measures of nightlights do not increase, this effect may be a reshuffling of people and economic activity into the periphery of treated regions.

The geography of road infrastructure also influences where residents and firms locate within a city, as access to commuting options increases both firms’ access to workers and residents’ access to desirable areas and jobs. If residents value transportation options, then infrastructure can also lead to sorting along socioeconomic lines if wealthy residents have a higher willingness to pay than poor residents for transit amenities. Tsivanidis (2023) studies the development of the TransMilenio BRT in Bogota using a quantitative urban model of commuting. His model highlights why the gains from a transit option are larger than just time saved, as firms and workers benefit from improved market access. He also finds that the benefits of the expansion were not particularly pro-poor: despite the fact that the poor use public transit

more, general equilibrium changes in wages and housing prices hurt them more, on net.[8] Furthermore, because he finds that low wage workers are more indifferent between the location of work than the rich, the poor were less affected by the previously high transportation costs that kept them working near where they lived. Balboni et al. (2020) also use a quantitative spatial model to study the development of a BRT line in Dar es Salaam. They find that the gains were slightly pro-poor as there do not seem to be strong preferences among residents for living in certain locations nor strong localised externalities.

Transit mode options matter, but so does the quality of the road itself. Gonzalez-Navarro and Quintana-Domeque (2016) implement an experiment to study road paving in Mexico and find that property values increased along paved roads and that residents were able to leverage these increased property values to increase durable good consumption. This paper also provides a rare opportunity to estimate how much residents value transit in a developing context; while there is a well-established literature in developed countries that uses changes in housing prices (hedonics) to study how much residents value access to transportation,[9] this has largely eluded developing country settings which may have incomplete property rights and frequently lack data on property transactions and prices.

5.1.2 Roads and congestion

New data sources from popular cell phone applications have opened opportunities to study traffic and congestion, revealing just how slow speeds are in developing country cities. Delays, measured in the minutes it takes to travel one kilometre, are 3-6 times larger in Jakarta and Delhi than in Los Angeles (Hanna et al. 2017), and speeds in rich country cities are about 50% faster than in poor country cities (Akbar et al. 2023b). While some of this difference in speeds is due to traffic congestion, poor infrastructure quality and design can also imply that speeds are slow even without traffic; Akbar et al. (2023a) characterise travel costs in Indian cities and find that Indian cities are very slow even at hours without congestion.

Just how costly congestion and slow speeds are to commuters is unclear. Kreindler (2022) approaches this question by pairing a structural model with an experiment that introduces a type of peak hour pricing and finds that congestion incurs little deadweight loss. This result is driven by the finding that commuters have strong preferences for departing at a given time, suggesting that policies that attempt to shift traffic patterns are unlikely to be effective. Akbar and Duranton (2017) reach a similar conclusion in a different setting using very different methods. They use synthetic trips generated by Google Maps to estimate the elasticity of the time cost of travel with respect to vehicles and find that the time cost of travel is very unresponsive to the number of commuters which implies a small congestion externality.

Independent of the size of the congestion externality and the inefficiency it causes, slow speeds cost commuters hours of commuting time a year. While policies such as congestion pricing, HOV lanes, and congestion zones are commonplace in many developed country cities, there is little evidence on their effectiveness in developing countries. One paper that studies congestion policies is Hanna et al. (2017), who study the removal of HOV lanes in Jakarta. Comparing traffic on HOV roads and alternative roads before and after the change, they find that delays are significantly worse on both formerly-HOV and alternative roads when HOV is eliminated. While evidence from the US supports the "Fundamental Law of Road Congestion", the idea that increasing the quantity of lanes is not an effective strategy for alleviating congestion as more cars enter when speeds increase (Duranton and Turner 2011), developing country cities often have a much lower stock (supply) of roads which may be inadequate given recent urban growth. Apart from congestion, road quality, route placement, traffic policy, encroachment into the street, or driver behaviour may be behind the slow speeds experienced in developing countries (Akbar and Duranton 2017, Akbar et al. 2023b), suggesting a different set of policies that could increase speeds by addressing these other causes.

5.1.3 Other externalities of road transportation

8 Warnes (2021) uses a dynamic model to study the effects of the BRT on sorting in Buenos Aires, finding that the welfare impact depends on the initial distribution of skills across space.

9 See Gibbons and Machin (2005); Billings (2011), among others for developed countries.

Congestion is not the only externality generated by vehicles; cars and traditional buses emit greenhouse gases, carbon monoxide (CO) and particulate matter (PM) which can have direct effects on residents' health. Indeed, the high concentrations of pollutants present in developing cities may mean that these damages could be larger than those found in developed settings (Arceo et al. 2016). Adding to the regulatory challenge of vehicle externalities in these contexts (Davis 2008, Oliva 2015) is the fact that the fleet in these cities is often older, and thus more polluting, noisier, and less safe on average (Barahona et al. 2020). Another potential externality is public safety. Road accidents kill 1.3 million people each year worldwide, mostly in developing countries. Habyarimana and William (2015) evaluate the impact of evocative messages on road accidents delivered on stickers placed inside Kenyan matatus or minibuses. They find that the intervention is effective and can reduce road accidents and average moving speeds in the vehicles assigned to treatment. More research is needed on how cars in developing cities can and should be regulated in light of these factors, and what the external costs of vehicular transit are in rapidly motorising developing cities.

5.1.4 Do developing country cities have the right amount of public transportation?

An important policy question is how much transportation is optimal and how transportation systems should be designed. Kreindler et al. (2023) study the development of a BRT system in Jakarta by pairing the empirical setting with a network routing model. They find that given a fixed number of buses, the optimal BRT network would be substantially more extensive than the existing network, despite the fact that this expanded network would imply longer wait times which commuters dislike. Similarly, Conwell (2023) studies minibuses in South Africa, and using a matching model for buses and commuters finds that minibuses are under-provided in the city; welfare would increase as wait times decrease with increased bus provision. These findings complement evidence from recent investments in formal, public BRT systems that deliver positive welfare gains to residents (Tsivanidis 2023, Balboni et al. 2020), suggesting that public transit options have not maxed out their potential in these cities.

5.2 Subways, light rail, and cable cars

Roads are not the only method of movement in urban areas; subways and light rail circumvent road congestion by having their own dedicated rails, and cable cars have emerged in developing country cities with settlements located on rugged or steep terrain.

5.2.1 Effect of rail transportation on cities

Like highways, rail transportation also lowers commuting costs from the periphery, but the limited spatial access to rail lines mutes the potential to induce sprawl relative to roads. Using data from night lights, Gonzalez-Navarro and Turner (2018) indeed find that subways cause cities to decentralise, but the effect is smaller than that found for highways. Within a given city structure, these transportation methods can have consequences for the geography of economic and other activities in a city.

Zarate (2023) combines empirical evidence from subway openings with a quantitative spatial model to highlight how access to transit can mean access to formal jobs for workers in remote locations. He finds that the gains from new subways are significantly amplified when one takes into account the increased labour market efficiency of better-connected workers. Using similar methods, Khanna et al. (2022) study the effect of the rollout of cable car stations in Colombia, finding that inhabitants of high-crime neighbourhoods where cable car stations opened were less likely to be arrested for a crime and more likely to be formally employed. Together, these papers show how transportation options in urban areas have the potential to connect residents to opportunity.

Other novel work has looked at the effect of rail transit on innovation. One recent example is Koh et al. (2022) who study the case of the Beijing subway system expansion and find that an hour reduction in travel time between two locations causes the number of patents on which innovators located in those locations collaborated to increase by 15% to 38% on average.

5.2.2 Urban rail and externalities

Rail is often cited as a promising solution to urban air quality problems, as it is typically powered by electricity and has the potential to displace trips using internal combustion vehicles. Gendron-Carrier et al. (2022) use satellite measures of particulate matter to study the impact of subways on urban air pollution and find that subways decrease air pollution by about 4%, but only among cities that at baseline have high pollution levels (above 28 µg/m3 PM2.5). As their discussion emphasises, the potential for rail to decrease emissions or congestion depends critically on the substitution patterns of commuters and whether or not they replace vehicle trips with rail trips. Gu et al. (2021) find corroborating evidence of subways substituting for motorised trips using the experience of China's subway expansions. When a new subway line opens, they find 4% faster automobile rush hour speeds along the direction of the subway line, consistent with substitution, and providing evidence of the mechanism underlying the improved air quality result in Gendron-Carrier et al. (2022). While growing, this small subfield requires further study using developing country data to better understand residents' travel mode decisions and the consequences that these preferences have for the ability of public transportation to address urban externalities.

5.3 Discussion and open questions

Intracity transportation modes connect residents and firms, and generate benefits beyond just travel time saved by increasing firms' access to workers and workers' access to jobs. In spite of recent advances, there is still a lot to be learned about transportation in urban areas. The internal structure of cities is challenging to study because finely disaggregated data on residents, firms, commuting, and property prices are frequently unavailable in developing country cities. However, in recent years new, innovative sources of data from satellites, cell phones, private pollution monitors, Google Maps, and others are making new areas of empirical study possible.

One set of open policy questions is centred around the provision of public transportation and its costs and benefits. There is scant evidence on what politically feasible policies would be effective at expanding and improving the quality of public transit systems in developing country cities (a problem made salient by the low quality of the Jakarta BRT documented in Gaduh et al. 2022). For example, what is the substitutability or complementarity between different transit options and how does this affect the magnitude of the gains to residents? On the cost side, does the geography of a city matter for the costs and feasibility of infrastructure investments? Moreover, it is also critical to understand how the spatial structure of cities may determine the optimal transportation network and the amount of public transportation. There are two patterns of urban spatial growth: cities that grow outward and remain relatively low-built and cities that grow vertically and need less land to expand (Lall et al. 2021). Ahlfeldt et al. (2023) find that the construction of tall buildings between 1975 and 2015, driven by reductions in the costs of height, has allowed cities to accommodate larger populations on less land. In that sense, evaluating the design of transportation networks and the amount of public transit in contexts where technologies to build tall buildings are cheaper is critical.

As incomes rise, it is also unclear how cities will fare under increased motorisation or if increased motorisation is an inevitable consequence of higher incomes.[10] Likewise, less is known about the impact of new technologies such as ride-share apps and the rise of delivery services on the transportation landscape of developing cities.[11] Finally, quantifying the magnitude of the mortality and pollution externalities associated with private vehicle use is an important area for future research as the size of these costs is a critical input for determining optimal regulation.

10 In this vein, a recent working paper by Du and Rothenberg (2023) proposes a spatial model to predict welfare and inequality impacts of lowering costs of vehicle ownership in Jakarta.

11 For example, Christensen and Osman (2023) use an experiment with Uber in Egypt to estimate mobility demand elasticities. They find that a 50% discount quadruples Uber usage and significantly increases users' total mobility, especially women.

6 Conclusions

The large literature on land transportation in developing countries has found that transportation infrastructure has the potential to generate large gains. While these gains have largely been found to be aggregate growth effects and not just a reshuffling of economic activity between locations, not all places benefit equally from transportation investments. In particular, intercity transportation options tend to benefit relatively more developed or industrial areas more than rural or less developed ones, and the literature has not found clear evidence that rural roads have a transformative impact on rural villages. By connecting residents to jobs and amenities, intracity transportation has been shown to generate significant gains in productivity, innovation, and connecting residents to formal work, but care should be taken to design urban infrastructure in a way that takes into account environmental externalities.

The literature on land transportation in developing countries is growing rapidly, invigorated by the rapid rate of urbanisation taking place, newly available spatial data, and the embrace of international trade models for the study of infrastructure effects. In recent years, the infrastructure impacts literature has benefited from applying the causal identification toolkit like instrumental variable and regression discontinuity methods to obtain exogenous variation in infrastructure. This has allowed a better understanding of the impacts of these investments and provided a way to address localised spatial spillovers of infrastructure. The other influential methodological innovation in the literature has been the use of trade models to estimate general equilibrium effects of infrastructure. These models allow infrastructure changes in some parts of the network to affect all nodes and propose models that capture indirect effects.

Some exciting areas of research that are only now emerging focus on the dynamic impacts of infrastructure and the interaction with market failures like pollution externalities. We believe that using new granular data, such as mobile phone data, will provide new insights into the benefits of transportation infrastructure and how these projects interact with other aspects of the economy. An emerging trend is the growing interest in studies of infrastructure that pay more attention to distributional effects. Finally, we noted a need for better cost of infrastructure data to be able to compare costs *and* benefits between competing investment alternatives. More subtly, developing countries present an exciting opportunity for academic research investigating how infrastructure investments are selected, financed, and located in an environment of weak institutions in which political or corruption concerns may play an outsized role.

We end by pointing to the emerging literature focused on optimal transportation networks as opposed to work that evaluates ex-post the impact of different transportation investments. A prominent example of this literature is Fajgelbaum and Schaal (2020) who study the best way to allocate transportation infrastructure in a general equilibrium framework. This kind of work has the potential to be influential for placement and total investment decision-making in developing countries.

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