REVIEW ARTICLE

Transport Policies and Development

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ABSTRACT This survey reviews the current state of the economic literature, assessing the impact of transport investments and policies on growth, inclusion, and sustainability in a developing country context. It also discusses the specific implementation challenges of transport interventions in developing countries.

1. Introduction

In developed economies, transport investments and improved technology over the last century have resulted in a continuous decline in transport costs, which in turn stimulated growth and economic development. In low- and middle-income countries alike, the current potential for transport policies to boost sustainable and inclusive growth appears to be large. This is especially the case given significant backlogs of transport infrastructure investment in both rural and urban areas, weak governance and inadequate regulations in the transport sector, and rising social costs in terms of congestion, pollution and accidents, especially in emerging large cities. For example, transport costs in Africa – with its poor infrastructure network – are considerably higher than elsewhere. Transport between Doula and N’Djamena (in Cameroon and Chad, respectively) costs on average 11 US cents per ton-kilometre, versus 5 US cents per ton-km in France and 4 US cents in the US (Teravaninthorn & Raballand, 2008).

Transport investments can be very large and transformative in their nature, leading or accompanying structural change (that is, the movement out of agriculture into industries and services). They may be needed to accompany the fast pace of urban growth currently occurring in Africa and Asia. While the provision of transport is potentially crucial for development, its impact depends on a variety of factors. Because these factors are not well understood, there is often a risk that transport investments are not cost-effective and do not produce the range of expected outcomes. Setting priorities in the strategic use of scarce resources should rely on a detailed understanding of how transport policies can produce growth-inducing effects and reduce social costs.
The objective of this paper is to review the broader direct and indirect benefits and costs of transport investments and policies in developing countries. We focus primarily on recent empirical literature, which, given advances in econometrics, has become increasingly robust. This literature covers a variety of issues, each study shedding light on a specific aspect. The largest share of papers looks at roads and, to a lesser extent, railways. Air and sea transport tends to be much less studied and this review reflects this bias. For evidence on industrialised countries, we refer the reader to recent literature surveys by Redding and Turner (2014) and Deng (2013). Straub (2011) and Trebilcock and Rosenstock (2015) review evidence from developing countries on infrastructure broadly defined, and Beuran, Gachassin, and Raballand (2015) focus specifically on roads in sub-Saharan Africa.

To account for the variety of mechanisms through which transport policies matter from a development perspective, we start in Section 2 by presenting a simple conceptual framework that details the links between the various interventions and impacts. Section 3 summarises the lessons from the literature, distinguishing effects on growth, inclusion and sustainability, and focusing mainly on papers published on developing countries. Finally, Section 4 concludes by discussing the implementation challenges faced by policy makers. The Online Appendix presents a general econometric framework for transport impact assessment and discusses, in light of this framework, how the recent literature addresses the main identification challenges.

2. Conceptual Framework

There are three broad types of transport policies: infrastructure investments, price instruments, and regulations. Investments entail building new transport infrastructure (for example roads, railways, or airports), upgrading existing links and technology, or improving transport services. Price incentives include subsidies or taxes to influence mode choice and transport behaviour more generally (for example, student fare reductions, tolls, parking fares, fuel taxes, and clean transport subsidies). Regulations include rules to directly reduce emissions (such as fuel emission standards, or driving restrictions) or to organise the transport sector (for example, freight, taxis or buses) or the construction of infrastructure. Some policy interventions may affect supply, such as infrastructure investments, whereas others target demand, as do transport subsidies.

A useful categorisation of the broader objectives of policies can be (i) to stimulate growth (for example, through lower transport costs, which facilitates agglomeration effects, trade and structural change, and leads to higher productivity), (ii) to facilitate social inclusion (for instance, through better access to transport services, which can enhance economic opportunities for the poor), and (iii) to improve sustainability (for example, through reduced health and environmental externalities). The extent to which these broad objectives can be reached depends on the behavioural responses of firms and households to policy interventions in terms of trade, location and mode choices. This is represented in Figure 1 below.

Figure 1. Impacts of transport policies: the mechanisms.
The literature on the impact of transport policies covers a variety of interventions and outcomes at different geographic levels. Studies have analysed very different aspects from rural tracks and feeder roads to global trade. Given the variety of interventions, mechanisms and outcomes, a simple way to formalise the impact of transport policies is to consider how policies affect the welfare of individuals or groups, or the profits of firms, through all possible channels. If we denote \(i (=1, \ldots, I)\) an individual/household (respectively a firm), and \(j\) a location \((=1, \ldots, J)\), the indirect utility of individual \(i\) in location \(j\) (respectively the profit function of firm \(i\) in location \(j\)) can be written as:

\[
V_{ij}(f^1(T,X^1), f^2(T,X^2), \ldots, f^E(T,X^E))
\]

where \(V_{ij}\) is the indirect utility of individual \(i\) (or the profit of firm \(i\)) at location \(j\) and each \(f^e\) (for \(e = 1, \ldots, E\)) is an outcome function which depends on the state of the transport system denoted by vector \(T\), and on a vector of exogenous contextual variables that matter for outcome \(e\) denoted \(X^e\). \(^1\)

Outcome functions may represent any argument entering the utility function of individuals or the profit function of firms. For individuals, outcome functions would include all relevant variables affected by transport such as employment status and wage, access to amenities, prices of consumption goods, residential land rents, pollution externalities, health and education status, exposure to crime, and so forth. \(^2\) For firms, the outcome functions would include elements such as the effective size of demand (market access) or the Marshallian externalities of learning, sharing and matching (see Fujita & Thisse, 2002) facilitated by the transport system.

A transport policy can be written formally as a change in the transport system \(\Delta T\) which induces a change in the indirect utility function or profit as given by:

\[
\Delta V_{ij} = V_{ij}(f^1(T + \Delta T, X^1), f^2(T + \Delta T, X^2), \ldots, f^E(T + \Delta T, X^E)) - V_{ij}(f^1(T, X^1), f^2(T, X^2), \ldots, f^E(T, X^E))
\]

Equation (2) accounts for the fact that several outcomes may happen simultaneously following a transport policy intervention, and that the impact of a policy may depend on the contextual variables. Many empirical studies, however, only focus on one of these outcomes (for example, on whether road investments increase wages) without considering the full set of effects. Contextual variables and long run effects are also very often neglected in the analysis. \(^3\) Note that not all outcome functions in Equation (2) need to be positively associated with a greater utility: whereas some effects can be desirable (for example, an increase in wages from the perspective of workers), other effects may be unwanted (such as pollution). Effects may also be heterogeneous in the sense that policies may differently affect different types of agents. For instance, better accessibility may improve the profits of local businesses but can harm a subset of renters in a targeted area due to the capitalisation of accessibility in housing values. Policies may also have heterogeneous effects within a class of agents: poor households, for instance, may respond differently to a change in price incentives than richer ones. Policies may also affect locations differently: an expansion of the transport network may induce relocation of activities from one place to another, with potential gains in one place but losses in the other. \(^4\) Therefore, it can be important to consider general equilibrium effects – including changes in prices – to assess the systemic impacts of policies. Formally, the impact of a transport intervention is assessed by considering the vector of changes for all agents in all locations:

\[
\Delta V = \Delta V_{ij} \text{ for } i = 1, \ldots, I \text{ and } j = 1, \ldots, J
\]

where \(\Delta V_{ij}\) is given by Equation (2).

Depending on the focus – whether systemic or partial – the literature has adopted various approaches ranging from equilibrium type models (spatial computable general equilibria, structural estimations of trade and economic geography models) \(^5\) to reduced form analysis, with different
geographic scopes and identification strategies. In what follows, we summarise the main findings from the recent empirical literature, in light of relevant elements of theory.

3. Lessons from the Literature

In line with our conceptual framework and reviewing mainly recent studies that apply a robust identification strategy, this section sequentially summarises the links between transport policies and growth, inclusion, and sustainability.

3.1 Growth

In principle, investing in transport should reduce costs, leading to an increase in productivity and shifting the economy to a higher growth equilibrium (see the Big Push Theory of Rosenstein-Rodan, 1943; further developed by Murphy, Shleifer, & Vishny, 1989; and Agénor, 2010). Empirical tests at the macro level confirm that transport investments can have a significant impact on growth. Calderón, Moral-Benito, and Servén (2015) estimate that the elasticity of output with respect to a synthetic infrastructure index—which includes transport along with electricity and telecommunications—ranges between 0.07 and 0.10. Similar impacts are found in the case of sub-Saharan African countries (Boopen, 2006; Calderón & Servén, 2010).

Various papers, which we present below, have looked in more detail at the different channels through which transport investments influence growth, including firms’ decisions to trade and choose locations, income and employment generation, and structural transformation.

3.1.1 Trade. A reduction in transport costs may stimulate the volume of trade, open up new markets, induce new industries to form, and thereby influence the patterns of trade. Trade costs are very high in much of the developing world. In Ethiopia and Nigeria for instance, trade costs are four to five times larger than in the United States (Atkin & Donaldson, 2015). A significant portion of trade costs in developing countries, especially in African countries, is actually non-physical (Raballand, Macchi, & Petracco, 2010), reflecting costs and delays associated with border crossing, price mark-ups of non-competitive transport firms, and bribes. For Uganda, it has been estimated that the costs associated with infrastructure inefficiencies represent a greater tax on exporters than trade policy (Milner, Morrissey, & Rudaheranwa, 2000). In Africa generally, delays at borders and ports can last between 10 and 30 hours (Foster & Briceño-Garmendia, 2010).

The decrease in transport costs was a major driver of the increase in international trade since 1950 (Hummels, 2007). Trade strongly depends on transportation networks as evidenced by an earthquake in Chile which had a negative impact on firms’ exports (Volpe Martincus & Blyde, 2013). Decreasing costs should stimulate exports: Freund and Rocha (2011) find that a one day decrease in over-land travel time leads to a 7 per cent increase in Africa’s exports. Similarly, simulations show that upgrading the primary road network connecting major cities would increase trade within sub-Saharan Africa by $250 billion over five years (Buys, Deichmann, & Wheeler, 2010). Interestingly, improving transport is found to have a greater impact on export performance when the country’s income level is lower (Portugal-Perez & Wilson, 2012).

Reduction in trade costs matters because it improves access to markets. Some papers directly measure the impact of better market access (proxying for better opportunities to trade) on various economic outcomes. In sub-Saharan Africa, smaller travel time to the nearest market (defined as a city with at least 100,000 people) is associated with an increase in agricultural production (Dorosh, Wang, You, & Schmidt, 2012). In another regional study on sub-Saharan Africa, it was estimated that a 1 per cent increase in a country’s market access is associated with a 0.03 per cent increase in its GDP per capita (Bosker & Garretsen, 2012). In Peru, Volpe Martincus, Carballo, and Cusolito (2014) find that a road improvement programme led to a significant increase in firms’ average annual growth rate of exports (6.4%) and subsequently in employment (5.1%).

Other papers focus on how a reduction in inter-city transport costs is likely to affect the diversification or specialisation of cities. Anas and Xiong’s (2003) model predicts that infrastructure associated with low transport costs (railways and highways) should lead to more specialised cities, while lower
cost trading services (telephone and Internet) should lead to diversified cities. The logic is that as transport infrastructure becomes less expensive, cities benefit from specialising while cheaply importing the goods they do not produce. Empirically, the effect of city roads is moderately stronger on the value of trade than it is on the weight of the goods traded, which can be interpreted as roads shifting economic activities within cities towards lighter goods in Colombia (Duranton, 2015).

Transport investments may have heterogeneous impacts across space with respect to trade and specialisation. In India, Donaldson (in press) finds that colonial railways built in the nineteenth century lowered interregional trade costs and price gaps, increased trade flows, and increased real income per unit of land area during the colonial period. In turn, this increased incomes within regions with railroads, but not always in areas without railroads. In China, Faber (2014) finds that reducing transport costs can lead to a reduction in industrial growth among connected peripheral regions relative to non-connected areas.

3.1.2 Firms’ location decisions, clustering and productivity effects. Improved transportation may lead to a re-allocation of manufacturing along the transport network. Ghani, Goswami, and Kerr (2015) highlight this impact in terms of clustering of manufacturing activities and the resulting enhanced productivity, consistent with insights from Economic Geography. The authors find that a major inter-city road investment in India (the ‘Golden Quadrilateral’) caused higher entry rates of manufacturing firms near improved highways and that these firms have higher labour productivity and total factor productivity. Focusing on the same road improvement programme, Datta (2012) finds that firms located near highway improvements are actually run more efficiently (storing inventories for less time). Interestingly, the effects can differ across industries. In Indonesia, massive upgrades to the highway system during the 1990s actually led to the dispersion of durable manufacturing activities and the clustering of perishable goods (Rothenberg, 2013). There may, however, be trade-offs regarding the location of investments: Lall, Schroeder, and Schmidt (2014) argue that transport investment in existing agglomerations will generate higher economic returns than in remote areas, but that the investment in rural areas, although generating lower returns, would be more beneficial to the poor.

3.1.3 Economic activity and income. Increased trade and productivity result in greater production and higher incomes. In the context of China, it has been found that infrastructure (roads and highways) have a positive effect on per capita GDP at the county level (Banerjee, Duflo, & Qian, 2012) and that it increased real income (see the structural estimation of Roberts, Deichmann, Fingleton, & Shi, 2012, based on a New Economic Geography model). In the case of Nigeria, Ali et al. (2015a) find that reducing transport costs significantly increases local GDP but note that the full impact of transport costs on incomes may only emerge slowly over time. In Ghana and Kenya, railway access has had a positive impact on economic development both in the short and in the long run (Jedwab, Kerby, & Moradi, in press; Jedwab & Moradi, 2016). In sub-Saharan Africa, Storeygard (in press) estimates that cities close to a main port grow faster.

3.1.4 Structural transformation. Improved transport networks may lead to structural transformation and the shift from subsistence to commercial agriculture. Lower transportation costs have been shown to cause an increase in the production of high-input crops at the expense of low-input crops (Ali et al., in press, on Nigeria). They also facilitate the adoption of modern farming techniques (see Ali et al., in press; on Nigeria, and Minten, Koru, & Stifel, 2013, on Ethiopia). Reduced transportation costs may also lead to a shift of production and labour away from the agricultural sector as evidenced by Gachassin, Najman, and Raballand (2015), who find that improved access to markets in Cameroon led to a diversification of the economic activities of households, especially among the most isolated households. For India also, it has been shown that new rural roads enabled workers to access external labour markets, leading them to shift away from agriculture (Asher & Novosad, 2016). Similarly, the construction of a new road in Vietnam was followed by the emergence of new non-farm activities (Mu & van de Walle, 2011). For Indonesia, Gertler, Gonzalez-Navarro, Gracner, and Rothenberg (2014) find that improved road quality increases job creation in the manufacturing sector and triggers an occupational shift from agriculture to manufacturing. In Nigeria, falling transportation costs both
decrease the probability of agricultural employment by households, and increase the likelihood of full employment (Ali et al., 2015a).

When transport costs remain high, however, as in the rural areas of sub-Saharan Africa, people will remain located near the spatially diffused sources of food production, thus preventing structural transformation by hindering the movement of people out of subsistence into the modern sector (see the model of Gollin & Rogerson, 2014).

3.2 Inclusion

High transport costs may also have direct effects on various dimensions of poverty. The literature has focused on how poor transport can affect vulnerable groups through reduced trade, adverse labour market outcomes, poor education and health, as well as crime.

3.2.1 Rural poverty. In rural areas of developing countries, there is a general lack of infrastructure investment given its major costs, lack of available funds and lack of political will (see, for instance, Blimpo, Harding, & Wantchekon, 2013, who show that there is underinvestment in roads in politically marginalised areas in four West African countries). This is all the more problematic as poor accessibility can be especially harmful for the rural poor (see for example, Fafchamps & Shilpi, 2009, who find that geographic isolation is associated with lower welfare in Nepal). In Uganda, Kyeyamwa, Speelman, Huylenbroeck, Opuda-Asibo, and Verbeke (2008) find that high transport costs deter farmers from participating in local markets to sell their cattle, relying instead on farm gate sales, which reduces their income-generating opportunities. Similarly, in rural Kenya, land devoted to cash crops is limited to areas in proximity to markets (Omamo, 1998). There is therefore a large potential for transport infrastructure investments to improve the living standards of the rural poor through better connections to market. Different dimensions of poverty may be impacted. Jacoby and Minten (2009) find that lower transport costs increase the income of remote households in Madagascar. In rural China, Emran and Hou (2013) find that better access to domestic and international markets improves per capita consumption and the livelihoods of the poor. Focusing on Bangladesh, Khandker, Bakht, and Koolwal (2009) find that rural road investments reduce poverty, including through higher agricultural production, higher wages, lower input costs, and higher output prices. They conclude that road investments are pro-poor, with gains that are proportionately higher for the poor than for the non-poor. This is consistent with the finding that benefits from rural road improvements are greater in poor communities, where levels of initial market development are lower (see Mu & van de Walle, 2011, on Vietnam). It has also been found that road accessibility has impact on population movements, as road improvements reduce incentives to migrate out (Gachassin, 2013, for Tanzania) and increases incentives to migrate in (see Fafchamps & Shilpi, 2013, for Nepal). Impacts on inequality are more nuanced, as Jacoby (2000) finds that although roads improve welfare of poor rural households in Nepal, they do not reduce inequality.

3.2.2 Urban labour markets. Regarding the labour market impacts of transport costs, a large urban literature has focused on how poor physical connections between jobs and residences exacerbate the unemployment and low wages of vulnerable groups and unskilled workers. The main idea is that when the poor are not well connected from jobs, they experience prohibitive commuting or search costs that are detrimental to their finding or holding of a job (see Gobillon, Selod, & Zenou, 2007; and Gobillon & Selod, 2012, 2014; for reviews). Although the overwhelming bulk of the spatial mismatch literature is centred around the United States’ case, it is certainly very applicable to the sprawling cities of the developing world where the disconnection from jobs could be an important contributor to poverty. To date, however, only a few studies have explored this likely important issue in developing country contexts. In Cape Town, South Africa, Rospabé and Selod (2006) find that an individual’s probability of unemployment is positively correlated with the commuting lengths of employed workers from the same neighbourhood. Using a randomised control trial in Addis Ababa, Ethiopia, Franklin
(2015) finds that randomly assigned transport subsidies to unemployed youth increases their probability of finding a job in the short term. In view of the above results, there can be an important role for transport policies to better connect people to jobs.

3.2.3 Education. Upstream to the labour market, transport costs also have an impact on educational opportunities and choices. In the rural areas of Bangladesh, Khandker et al. (2009) find that improving rural roads leads to higher rates of both boys’ and girls’ enrolment in school. Similarly, Jacoby and Minten (2009) find a positive impact of road investments on higher secondary school enrolment in Madagascar.

3.2.4 Health. There are also potential food security and health benefits from better transportation. In a study of West Africa, Blimpo et al. (2013) find that areas with less transport access likely suffer more from food security problems, as evidenced by stunting. This is because food prices are correlated with transport costs (related to road quality) as shown by Minten and Kyle (1999) in the case of the Democratic Republic of Congo. In Ethiopia, improved market access has been found to have a positive impact of on household nutrition (Stifel & Minten, 2015). There is also evidence that penetration of rural areas by railroad helps poor communities be more resilient to negative agricultural productivity shocks threatening the food supply (see Burgess & Donaldson, 2012, on nineteenth and early twentieth century India).

More generally, lowering transportation costs significantly reduces the probability that a household is multi-dimensionally poor through improvements in health, education, and standard of living (see Ali et al., 2015a, who correlate a multi-dimensional poverty index with transportation costs in Nigeria).

3.2.5 Crime. Finally, as the poor are disproportionately exposed to crime, a strand of the literature has analysed the relation between crime and transport. Crime in transport is a serious issue in developing countries. This is illustrated by the case of South African urban public transport which has high incidences of murder, rape, and assault (see Kruger & Landman, 2007). Women are especially vulnerable to security issues because they are more dependent on public transport (Babinard & Scott, 2011). Beyond crime repression, investment in physical infrastructure has an impact on reducing crime. In the case of Bogotá, Colombia, Marcelo (2013) finds that crime decreases around new Transmilienio (bus rapid transit) stations, an effect the author attributes to better lighting at night. Similarly, the construction of the cable cars (Metrocable) in Medellín, Colombia was accompanied by neighbourhood upgrading (new social housing, schools, and other infrastructure improvements) which resulted in a decline in violence (Brand & Dávila, 2011).

The relation between transport availability and crime location is controversial and not well researched. In the developed world, the perception is that public transport attracts crime but available evidence does not back this up (Chainey & Ratcliffe, 2005; Ihlanfeldt, 2003). It should not be concluded, however, that improved transport will necessarily decrease crime. In the specific context of conflict areas in the Democratic Republic of Congo, Ali et al. (2015b) found that more accessible areas are actually more exposed to violent events, causing a decrease in population welfare.

3.3 Sustainability

Transport has significant social costs, which need to be balanced against potential positive economic impacts. These costs involve negative externalities, ranging from congestion, accidents, impacts on health caused by air pollution, and the easier spread of epidemics, as well as direct costs to the environment such as deforestation, biodiversity loss, and more generally degradation of ecosystems induced by transport infrastructure. In the long run, some of these negative effects may even be harmful to growth. Transport policies thus have a role to play to minimise and mitigate these negative impacts. We first describe the problems and then discuss policies to address them.
3.3.1 Negative socio-economic impacts. Congestion in transport is a major problem in both developed and developing countries involving high opportunity costs (time spent in traffic could be spent in leisure or in more productive pursuits).\textsuperscript{10} Congestion is also problematic given its contribution to air pollution caused by vehicle emissions. In developing countries, although car ownership is much smaller than in developed countries, traffic congestion and air pollution are often far worse (Fazal, 2006; Sperling & Claussen, 2004). Fatalities and injuries on the road exert a toll, especially on developing countries. Cubi-Mollá and Herrero (2012) report that in 2004 over 50 per cent of road fatalities worldwide were among economically active young adults, aged 15–44. Even when accidents are non-fatal, they can still be economically catastrophic, leaving people too disabled to work.

Roads can also help spread infectious diseases, as evidenced by AIDS following the road network in southern Africa (see Regondi, George, & Pillay, 2013). Mobility restrictions necessary during the recent Ebola epidemics likely had harmful economic impacts by interrupting the flow of trade (World Bank, 2014).

Finally, transport infrastructure may disturb the ecosystem through deforestation, biodiversity loss, pollution, road kill, and blocking of seasonal migration patterns of wildlife (see Chomitz & Gray, 1996; Laurance, Goosem, & Laurance, 2009).\textsuperscript{11} Furthermore, roads may exert cumulative negative impacts, with a toll that increases over time. In the Brazilian Amazon, for instance, the Belém-Brasília Highway, completed in 1970, today cuts a 400-kilometre-wide path through the rainforest (Laurance & Balmford, 2013).

3.3.2 Designing sustainable transport policies. Policies to address these issues, whether through investment, pricing, or regulation, will influence either the supply of or the demand for transport. There are different policy options available, generally with nuanced impacts.

Pro-growth infrastructure investments, while reducing transport costs and increasing travel speed have been shown, in developed countries at least, to increase congestion and air pollution as new roads actually increase traffic by either drawing traffic from alternative roads, stimulating commercial trucking, or attracting new drivers onto highways in the United States (Duranton & Turner, 2011) and Japan (Hsu & Zhang, 2014). Whether this trade-off applies to developing countries that are currently at various stages of development remains to be researched. A more clear-cut sustainable policy approach is to target investments at public transport systems. For instance, the opening in 1996 of the Taipei metro reduced carbon monoxide emissions between 5 and 15 per cent (Chen & Whalley, 2012).

Infrastructure investments also have a direct impact on the shape of cities, which in turn affects the level of congestion and emissions within cities. There is ample evidence in the developed world that transport infrastructure has caused the decentralisation of the population at the city level (Baum-Snow, 2007; Brueckner, 2000) as well as of jobs (Baum-Snow, 2010). This has also been the case for China (Baum-Snow, Brandt, Henderson, Turner, & Zhang, 2015). Using a panel of 138 cities around the world, Gonzalez-Navarro and Turner (2014) confirm the role played by subways in decentralisation. In the United States, these investments are believed to have contributed to urban sprawl (Brueckner, 2000) and carbon emissions from extensive car use (Glaeser & Kahn, 2004), there appears to be a role for transport policies in urbanising developing countries to influence the evolving shape of the city in a sustainable way (Suzuki, Cervero, & Iuchi, 2013). Avoiding ‘lock-in’ into unsustainable city patterns is important because investment in public transit to mitigate car use is very costly when carried out after city expansion. Influencing city shape in desirable ways through transport investment is, however, more easily said than done and requires appropriate planning, cognisant of the forces that shape cities. Using a core-periphery model calibrated on Beijing, China, Anas and Timilsina (2015) show that more efficient transport in the core area would attract population and thereby reduce carbon dioxide emissions, but that lower transport costs in the periphery would encourage suburbanisation, thus increasing carbon dioxide emissions.

On the demand side, pricing, through subsidising ‘good’ behaviour or taxing ‘bad’ behaviour, can also be a useful tool to alter incentives. Subsidising public transport may reduce emissions by
incentivising people to switch from driving to using public transit. The price instrument, however, is seldom used in developing countries (see Timilsina & Dulal, 2011, on urban road transportation externalities). This may be because subsidies are costly and taxation is politically difficult to implement (Anas & Lindsey, 2011; Timilsina & Dulal, 2011). Taxation (either a toll or fuel tax), however, can be efficient in reducing emissions by discouraging car use in cities (Anas & Timilsina, 2009). Using a calibrated land-use and commuting-choice model for Beijing, China, Anas, Timilsina, and Zheng (2009) find that a 10 per cent increase in monetary cost of travel would reduce carbon dioxide emissions by 1 per cent. Tolls should also reduce congestion and emissions by incentivising drivers to switch to public transport (Anas & Lindsey, 2011).

Rather than relying on incentives, policy makers can also mandate the desired behaviour through a variety of regulations (for example, catalytic converters, fuel efficiency standards, driving restrictions). In theory, fuel efficiency regulations may only have limited, short-term impacts on air pollution when they apply only to new cars and can only be gradually phased in (Anderson, Parry, Sallee, & Fischer, 2011). Their impact may also be offset by an increase in the vehicle-miles driven causing higher induced fuel consumption and emissions (see Small & Van Dender, 2006; Anas & Timilsina, 2009 on this rebound effect). Other types of regulations include driving restrictions during periods of high pollution generation. Quito, Ecuador, implemented a vehicle use restriction programme during peak driving (Pico y Placa) which was found to efficiently reduce emissions by between 9 and 11 per cent during peak hours and by 6 per cent during the day (see Carrillo, Malik, & Yoo, in press). In Santiago, Chile, peak-hour vehicle-use restrictions led to a shift to public transport systems as well as a shift in arrival and departure times (De Grange & Troncoso, 2011). These studies, however, tend to focus on the relatively short-term. Bonilla (2012) argues that in the long run, households will respond to such programmes by purchasing additional vehicles, thus reducing the effectiveness of the programme. This argument is consistent with the findings of Eskeland and Feyzioglu (1997) and Davis (2008) who study car use restrictions in Mexico (the ‘Hoy No Circula’ programme). Both papers find that car restrictions do not improve air quality and actually induce an increase in the number of vehicles in circulation, with people buying a second – often older and less fuel efficient – car. Other examples of regulations include more drastic measures such as those implemented by China in anticipation of the 2008 Olympic Games, combining plant relocation and furnace replacement with new emission standards and traffic controls. Pollution fell during and shortly after the games, but this effect was short lived given the temporary nature of the measures (Chen, Jin, Kumar, & Shi, 2013).

Finally, examples of potential regulatory tools aimed at reducing the negative environmental impact caused by road construction in forested areas are found in Damania and Wheeler (2015). They develop a novel index of biodiversity loss to guide the planning of road investments away from ecologically rich areas.

4. Discussion

In this section, we discuss the main lessons gained from the literature review both from the policy and research perspectives. The review presented the diverse mechanisms through which transport policies can induce beneficial outcomes, in terms of sustainable growth and inclusion, as well as the trade-offs encountered. Transport infrastructure investments play a major role in the process of economic growth, structural transformation, and urbanisation. Price instruments and regulations are useful tools to affect behaviour and address environmental externalities. In developing countries, however, transport policies are often poorly designed and implemented. Infrastructure investments are lagging and price instruments are rarely used (Foster & Briceño-Garmendia, 2010; Timilsina & Dulal, 2011).

The main lesson is that improving the transport network leads to a reduction in transport costs which in turn increases access to markets and boosts trade flows. Falling transports costs often induce firms to relocate to better take advantage of agglomeration effects. Structural transformation can also be triggered, with farmers moving from subsistence to commercial agriculture or to non-agricultural activities. These impacts lead to an increase in welfare, with higher incomes and lower poverty. Rural
feeder roads especially are found to be pro-poor. However, the potential gain to growth and inclusion must be balanced against the potential costs to the environment. Road investments lead to deforestation and biodiversity loss. Increased traffic on new roads leads to air pollution and detrimental health impacts.

Implementation of transport policies in developing countries faces a number of challenges. Obtaining funding for transport infrastructure investments is difficult in contexts of scarce resources and limited fiscal capacity (Sperling & Claussen, 2004). This is exacerbated by the fact that construction of infrastructure is particularly costly in developing countries given non-competitive procurement (Estache and Limi, 2009) or corruption (Collier, Kirchberger, & Söderbom, 2015). Today, in addition to using government resources and borrowing, there is an increasing emphasis on leveraging funds through public-private partnerships (see Trebilcock & Rosenstock, 2015). However, this requires the presence of a private operator and appropriate coordination between the public sector (which sets the strategy) and the private sector (which provides funds, construction, and operation). An innovative funding mechanism (although dating back to the nineteenth century) is to capture land value increases following an infrastructure investment (see Peterson, 2009). However, a prerequisite is that property rights on land must be well defined, which is not the case in much of the developing world.

When the infrastructure is in place, operation also requires funding (which can be scarce) or may be hindered by inefficient management (Bogart & Chaudhary, 2012), non-competitive market structures of service providers (Lall, Munthali, & Wang, 2009) or excessive regulations (Button & Keeler, 1993; Combes & Lafourcade, 2005), which further drives up user costs. These non-physical costs may represent a significant share of total transport cost, in particular in African countries (Teravaninthorn & Raballand, 2008).

Another implementation challenge, although not restricted to developing countries, revolves around the political economy that underpins transport investment choices and the resulting allocative inefficiencies. Ethnic favouritism and political clientelism influence the placement of road investments (see Burgess, Jedwab, Miguel, Morjaria, & Padró i Miquel, 2015, and Blimpo et al., 2013). This occurs at the detriment of investment in places where the return could have been greater, or that could have a greater poverty-reduction impact (for example, in light of the ‘pro-poor’ effect of rural feeder roads, see Jacoby, 2000; van de Walle, 2002).

There can be complementarities between transport policies. In other words, roads may be a necessary but not sufficient condition for development (Gachassin et al., 2015). For instance, the effectiveness of price incentives in shifting people towards public transport also depends on the quality and capacity of that network (Anas & Lindsey, 2011; Sperling & Claussen, 2004). Transport policies may also need to be combined with non-transport policies to produce the intended effects. For instance, better road connections will have an amplified impact on the development of commercial agriculture when combined with expanded cell phone coverage (Casaburi, Glennerster, & Suri, 2013), agriculture extension services, or access to credit (Ali et al., in press). Similarly, urban renewal programmes may require both transport investments and neighbourhood investments (Brand & Dávila, 2011). To address spatial mismatch, connecting unemployed workers to jobs may produce little effect in the absence of training to reduce the skills mismatch. At the macro scale, transport investment will have transformative impacts provided an enabling environment is present that allows for the development of a manufacturing sector and trade.

This literature review raises a number of issues for policy-oriented transport research in developing countries. First, conducting rigorous impact evaluations requires relevant data which are missing in many countries: as a general rule, the poorer the country and the greater the need for transport to support development, the less data are available. For most developing countries, there is little information available on transport costs and its various components, both physical and – maybe more importantly – non-physical. Not having information on the determinants and structure of costs hinders the design of well-targeted interventions that reduce barriers to trade. Similarly, data on internal commodity flows are almost non-existent in the developing world (with a few notable exceptions in Latin America, including Colombia and Mexico). This prevents empirical analyses of policies that facilitate trade between cities and industrial specialisation. When data on infrastructure are
available for developing countries, important attributes may be missing (such as the quality, surface or width of roads) and changes over time are rarely recorded. As demonstrated by a number of papers in this literature review, having historical datasets is needed for the study of long-term impacts of infrastructure investments or as instruments for causal identification. Although retrospective digitising of transport networks has been done on an ad hoc basis, such data are typically not made available to the wider research community. There is a need for better coordination of ongoing digitising efforts and sharing of processed data.

A second lesson is that current studies are rather restricted in their scope, for technical reasons or data limitations. Indeed, robust inference of causality may require localised case studies to the detriment of external validity. Focusing on a restricted area may provide a biased view of the impact, for instance by overlooking possible displacement of activities from outside the area of study. To address this issue, the design and estimation of structural models can be particularly relevant, especially for large scale transport investments that can affect a whole economy. However, applying structural models to a developing country context is challenging, not only because data for estimation and calibration may not be available, but also because existing models may need to be adapted (for instance, the standard assumption of free labour mobility may not apply). Another restriction in transport studies is often the exclusive focus on only one intervention (say the construction of roads) when other changes to the transport network may have taken place simultaneously (for instance because railroads developed in parallel). There is also scant research comparing the impact of alternative transport investments to inform the optimal sequencing and prioritisation of interventions.

Third, beyond the scope of the academic contributions to the transport literature, there are also complex and costly simulation tools (that is, land use and transport interaction models) that have been developed for urban planning for a few metropolitan areas in high-income countries (see for example, de Palma, Motamedi, Picard, & Nguyen Luong, 2005, for the Paris metropolitan area). Although still being improved, those models have the potential to be efficient tools for ex-ante assessment of transport infrastructure investments. However, because of data requirements and costs, they are not necessarily accessible to developing countries. Researchers are currently developing simpler versions of land use and transport interaction models that could be more easily implemented (Arnott, 2012), although a number of challenges remain to adequately account for the specificities of developing countries (in particular the coexistence of informal and formal land markets).

Among the areas of research yet to be explored in a developing country context are the impacts of transport policies on congestion. Further research is also needed to improve our understanding of how transport investments can spur labour reallocation between sectors and job creation. Price instruments which have proven effective in developed countries would need to be further tested and evaluated in the developing world.

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Notes
1. The framework can be extended to the case of endogenous contextual variables where the outcome functions are specified as \( f(X, A', G(T)) \). Consider for instance the study of how roads may impact deforestation, where \( f(X, A', G(T)) \) represents deforestation, \( T \) the length of roads, and \( G(T) \) the level of conservation enforcement. \( G \) may indeed depend on \( T \) if potential investors lobby the authorities for a weaker enforcement of conservation laws in response to the opportunities created by the investment.
2. Individual indirect utilities may be aggregated using a Social Welfare Function to characterise the welfare of a group.
3. Focusing on an urban labour market for instance, improving the density \( T \) of metro stations may lead to more matches \( f(,) \) between applicants and potential employers only if the skill distribution of unemployed workers (the context \( X' \)) matches that of labour demand.
4. In addition, policies may target specific groups or locations or may treat them differently, in which case a specific \( T_i \) can be substituted to \( T \) in Equation (2).
5. A particularly useful framework to assess the impacts of transport is the Eaton and Kortum (2002) model which yields structural equations for bilateral trade accounting for geographic barriers to trade, including high transport costs (see Burgess & Donaldson, 2012; Donaldson, in press; and Donaldson & Hornbeck, 2016).
6. This would cost $20 billion for the initial upgrade and $1 billion annually in maintenance.
7. Improved transport can also lead firms to be more productive as better roads can stimulate more intense vehicle use (Fernald, 1999) or reduce absenteeism (Van Ommeren & Gutierrez-i-Puigarnau, 2011).
8. The specific case of women, who may have fewer transport options, pay a large share of their income on transport, or face security issues in transport has been investigated only in a few studies (Blumenberg, 2004; Babinard & Scott, 2011; and Rosenthal & Strange, 2012).
9. Other policies can be to facilitate the residential mobility of workers (see Katz, Kling, & Liebman, 2001) or provide incentives to firms to locate in disadvantaged areas. These approaches, however, have led to mixed results (Gobillon, Magnac, & Selod, 2012).
10. In the United States, traffic congestion is detrimental to aggregate employment growth in US metropolitan areas (Hymel, 2009).
12. Note, however, that the effect may be offset by inducing pedestrians to use public transportation.
13. Other examples of calibrated models exploring the effects of externality pricing in developing country cities include Mexico City (Anas & Timilsina, 2015; Anas et al., 2009); Cairo (Parry & Timilsina, 2010); and Sao Paolo (Anas & Timilsina, 2009). These models are able to compare the efficiency of different taxes (such as gasoline tax versus car tolls).
14. It is notable that pricing instruments may have an impact on city shapes by influencing location and travel decisions (see Brueckner, 2014, in the case of cordon toll pricing).

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