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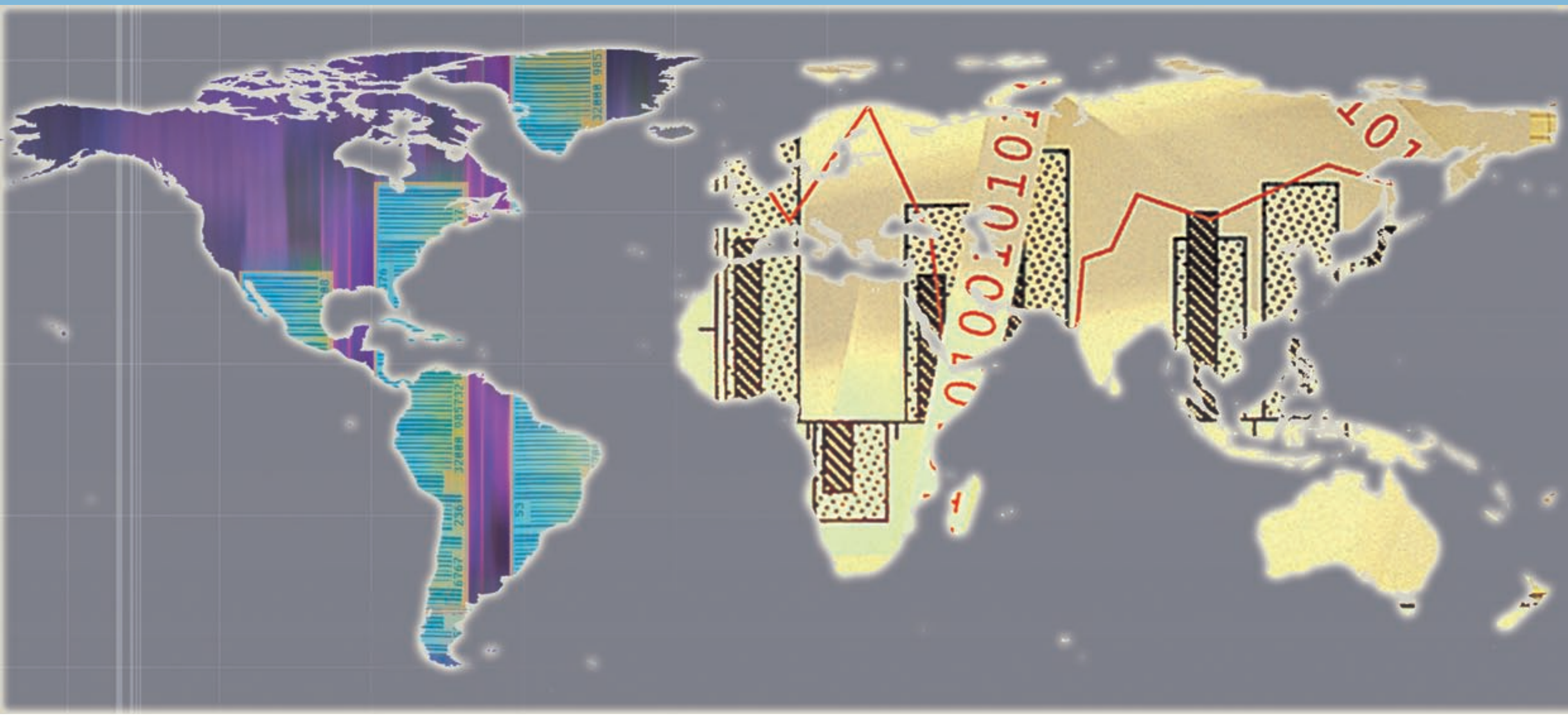

On Track for Industrial Development

UNITED NATIONS
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RESEARCH AND STATISTICS BRANCH
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On Track for Industrial Development

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Vienna, 2010

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Abstract

This paper speaks to two questions: firstly, to what extent does transport infrastructure explain why some countries have managed to industrialize while others have not? Secondly, can growth of transport infrastructure explain differential rates of industrialization? To answer these questions, a simple empirical model, drawing from the deep determinants literature as well as the one on structural change, is formulated and applied to nearly 80 industrialized and developing countries for a time period of 1970 to 2000. The answer to the first question is in the affirmative, especially at the lowest income levels and for the fast-growing Asian tigers. In terms of explaining differential growth rates, faster rate of investment in railway infrastructure is likely to spur industrial development in the Tiger economies, while for the other country groups this does not seem to be the case. This appears to be the case for road infrastructure as well, i.e., Tigers should increase their spending on roads. The overall conclusion is that transport infrastructure significantly explains long-term levels, but that in the case of the short-term concern, the growth dividend of road infrastructure is quite small.

Keywords: Transport infrastructure, manufacturing, industrial development, cross-country regression.

JEL Classification: C23; D24; H54; L60; L91 ; L92; N60; O14

1. Introduction

Perhaps the strongest argument one can make for investment in transport infrastructure is the importance of market size and the attendant connectivity to domestic and international markets. If the United States did not have its highway and railway network, this large country would effectively consist of numerous more or less isolated entities (states and cities) trading within themselves. Producers would be confined to small markets for their goods and services. Furthermore, they would only be able to use those inputs available to them in that particular area.

Also in the European Union is the perspective of connecting people and markets to create one grand market one of the main objectives. Again, transport infrastructure is critical for this vision to fully materialize. In fact, the OECD (2006) has calculated that, globally, about 3.5 per cent of world GDP annually needs to be allocated to new investment in infrastructure and maintenance, replacement and upgrading of the existing stock.[1] Developing economies will see more of the former, while industrialized ones will tend to focus on the latter.

An important aspect from the producers' point of view is the ability to reach minimum scale of efficiency in the production. Anything below that is bound to negatively impact on efficiency. Market size promotes productivity and, hence, prosperity. Physical isolation means a smaller pool of workers to draw from for firms. Moreover, the probability to find appropriate skilled labour ought to be negatively related to the size of labour market. Access to inputs, such as raw materials and machines, is also constrained. The area might not have access to the right kind of raw materials or it can only be delivered with considerable delay. The availability of machines is constrained by what is being produced in the area. On the whole, what can be produced depends on the existence of resources and constitutes a reminder of the autarky situation trade textbooks. Keeping congestion at bay and ensuring reliable supply lines, therefore, seem important for competitiveness and growth. To be sure, the propensity to export, competitiveness and the ability attract foreign direct investment depends on the state of infrastructure.

From a welfare viewpoint, most of the country's population would be deprived of a variety of goods and service and would, thus, enjoy less comfort and happiness than were they connected to the other entities of the country. Furthermore, Agenor (2009) convincingly

[1] This is the figure for total infrastructure, i.e., roads, railways, telecommunications, electricity and water.

argues that better transportation networks are important from a health and education perspective, e.g., by increasing access for patients to health facilities or reducing students' absenteeism from school. Long commuting distance is shown to be positively related to absenteeism, shirking and low worker productivity. It may also affect employers' decisions as to whom to fire or hire (van Ommeren and Gutièrrez-i-Puigarnau, 2009). This finding can be translated to developing countries, where poor transport infrastructure may lower labour productivity through this channel.

From the country perspective, without adequate transport infrastructure resources are not allocated to their best use and the exchange of ideas and information is impaired. Paradoxically, such benefits do not always seem fully appreciated until there is lack of transport infrastructure, e.g., until a bridge breaks down or there is traffic congestion.

To draw such drastic a picture helps illustrate the main point about the role of transport. Although it is far from the current situation in OECD countries, this may not necessarily be the case for many of the poorest ones. For example, a third of Africa's population lives in landlocked countries, underscoring the importance of railways and roads. Because of poor transport infrastructure, transport costs are very high and these costs are added to goods prices, which has a negative impact on demand and scope for industry to develop. Moreover, long and durable transport compromises the quality of goods such as fresh food, leading to severe production losses.[2]

While it is not difficult to find arguments for the importance of transport infrastructure in economic growth and industrial development, numerical evidence appears to be scarce. For example, most empirical work on infrastructure takes an aggregate view of the economy. The focus is on some aggregate such as GDP growth or GDP per capita levels. Interestingly, firm-level studies are quite common, often in perception fashion, e.g., whether firms perceive infrastructure to be a major problem. The meso-level of aggregation, i.e., agriculture, industry and services is more seldom in the lens, possibly with the exception of agriculture. Most studies focus on infrastructure through public capital and rarely directly consider physical measures of roads and railways. Although the entire stock of infrastructure indeed may

[2] Another example is Latin America, for which Calderón and Servén (2004b, a) show that infrastructure is an important determinant of GDP per capita growth. They also argue that the continent is lagging behind the international norm in terms of infrastructure quantity and quality. Based on growth accounting for Argentina, Brazil and Mexico, Herranz-Loncán (2009) shows the direct contribution of railways to GDP growth during the first globalization boom and how it exceeded that occurring in Britain and Spain (e.g., Herranz-Loncán (2007) provides a serious investigation into the Spanish case).

constitute a large part of public capital (see, for example, Munnell, 1992), this is a problem when only focusing on one facet of infrastructure. Moreover, the share of infrastructure in public capital differs across countries and the more infrastructures are being privately owned, the less perfect a measure of infrastructure is the stock of public capital.

The reasons for all of the above may partly owe to lack of data, but perhaps also to the fact that infrastructure may have been more of a concern to particularly development economists and policies for development. In industrialized economies, it is difficult to assess the impact of transport infrastructure because the data rarely allow for an analysis comparing before and after development. Conversely, in developing countries investment in infrastructure occurs during development. Typically, and largely thanks for the efforts of Canning (1995, 1998), data are available from 1960 and onwards, a time period during countries such as Republic of Korea and Taiwan (Province of China) went from low income to, in the first case, even become a member of the OECD. What can be done, however, is to examine cross country levels of development.

This paper attempts to fill this gap by taking an industry focus. It looks at the impact of roads and railways on industrialization for nearly 80 countries, with data spanning from 1970 to 2000. Industry here means the manufacturing sector and the paper, thus, focuses on the main privately-owned driver of aggregate growth. There is a long and short view. The long view is concerned with examining whether transport infrastructure can explain why some countries have industrialized, while others have failed to do so. The paper is also asking whether the rate of industrial development is affected by the rate of growth in transport infrastructure. This is the short-term view of affairs. Another dimension is the belief that transport networks have different impacts in different contexts. In particular, a country’s development stage may matter positively in at least two ways. First, countries with a relatively small road network should at the margin benefit more from another road. Secondly, the more important integration with the rest of the domestic and world economy becomes, the larger the impact of another road.

One needs to be mindful of statistical issues involved. The early literature, of which Aschauer (1989) is usually the representative, tended to estimate very large returns to public investment. Some, but not all, of these excess returns can be attributed to the adoption of less than perfect econometric techniques. More recently, awareness of endogeneity bias, omitted state-dependent variables correlated with infrastructure and better handling of nonstationary data have delivered more acceptable results or, at least, smaller elasticities. However, because of likely large externalities and infrastructures' cross-sectoral impact it is difficult to know what is actually acceptable.

Because the data being used here span space as well as time, panel-data estimators are employed, thus addressing some dimensions of omitted-variable bias. Both fixed and random-effects estimators are used despite well known concerns with the latter. However, a lot of variation may actually occur between rather than within countries and one needs to weigh that in. For this class of estimators, the potential endogeneity of transport receives particular attention as well. Instrumentation is always difficult, but a serious attempt is made to deal with it.

A preview of the results suggests that transport infrastructure, indeed, carries significant explanatory power for why some countries have succeeded to industrialize. In particular, the impact of railway infrastructure is large. For the preferred regression, a 10 per cent increase of railway infrastructure leads to an expansion of manufacturing per capita amounting to four per cent. The extent to which road infrastructure impacts on manufacturing depends on how such infrastructure is scaled in that roads are only significant when normalized with land area. For non-instrumental variables estimators normalized is not very important. The impact of a 10 per cent increase of the road network per land area, independent of it being paved or not, is 3.3 per cent. If paved, road infrastructure causes a five per cent increase of manufacturing. Hence, there is little doubt that transport infrastructure importantly relates to the success of industrialization efforts.

A hypothesis tested is that transport infrastructure would impact differently across stages of development. Based on railway per capita the largest effect, indeed, occurs at the lowest income levels, while in the case of railway per land area the indication is that for the lowest income group such infrastructure may actually be overprovided. In other words, normalization matters. For road infrastructure, especially paved roads, the largest effects are recorded for the fast-growing Asian tigers and the lowest income groups.

In terms of differential growth rates, for the sample as a whole railway infrastructure appears not to be statistically important, while growth of road infrastructure causes faster industrial development. Surprisingly, it seems more important to have faster growth of any road network than of paved roads, that is, the quality of road infrastructure is less important than having any road. Faster rate of investment in railway infrastructure is likely to spur industrial development in the Tiger economies, while for the other country groups this does not seem to be the case. This appears to be the case for road infrastructure as well, i.e., Tigers should increase their spending on roads. However, in this case also other country groups would benefit from investment in roads. Nevertheless, the general impression is that the growth dividend of road infrastructure is quite small.

The remainder of the paper is organized as follows: in Section 2, motivation for transport infrastructure is provided and the empirical literature reviewed. A simple empirical model is developed based on the literatures of structural change and so called “deep determinants” in Section 3, while Section 4 addresses some econometric concerns commonly voiced in the infrastructure literature. Data and their sources are described in Section 5 and the econometric results are dwelled in Section 6. Section 7 concludes the paper.

2. Transport infrastructure and the empirical literature

When it comes to transport infrastructure, the empirical literature is not very rich. There are three dimensions that are relevant to this paper, namely, direct measures of transport infrastructure, data on manufacturing performance and cross-country analysis. It is the combination of these three dimensions that reduces the volume of relevant empirical literature.

Firstly, because good data on roads and railways are rare, most cross-country studies focus on public investment. But public investment contains more than transport infrastructure and, therefore, drawing inferences from such investment for transport infrastructure can be misleading. Canning’s (1995, 1998) infrastructure database, however, is probably one of the best sources of cross-country transport data and it has rightly spurred some good research.

Secondly, most studies focus on aggregates such as GDP per capita and not manufacturing industry. While acknowledging the role of manufacturing for GDP performance, again it may be misleading to infer from aggregate studies the implications of transport infrastructure for manufacturing.

Thirdly, it is difficult to gauge the importance of transport infrastructure for countries that are already developed and, thus, have a large stock of such assets. However, studies of economic history provide a good source of information, but tend to be confined to one or, at least, a few countries only. Although the cross-country perspective is missing, an advantage is that the impact of transport on industry can be examined in detail for already developed economies and this is where this review will take departure from. Before that, however, some arguments for why transport infrastructure should be important for industrial development will be discussed.

2.1. *Arguments for transport infrastructure*

Before reviewing the literature, what are the arguments speaking for a positive impact of transport infrastructure on industry? Theoretically, Barro's (1990) seminal endogenous growth paper introduces government expenditure as a public good in the production function. The effect is to increase the rate of return to private capital which, in turn, stimulates private investment and growth.

In the Hulten and Schwab (1991) approach, there are two channels through which infrastructure affects output/TFP. First, roads are combined with vehicles, workers, fuel, and so on by the transport industry to produce transportation services, which, then, are sold to other sectors. The unpaid infrastructure inputs are converted to a paid factor of production in the downstream industry, and any improvement in the quantity and quality of the infrastructure network upstream appears as a cost reduction of the intermediate purchases of transportation services downstream, or as an improvement in the quality or scope of these services. Improved transportation lower the labour costs by expanding the pool of available workers or by reducing the cost of housing workers near the work place.

The second channel is indirect. The expansion of capacity of one point in an existing infrastructure system can have effects through the network through the addition or extension of critical links, or the elimination of bottlenecks. For example, lower transport costs may lead to an expansion in the size of product and input markets, in turn leading to efficiency gains through economies of scale and scope, increased competition and to greater input specialization. It may also permit the use of newer more efficient technologies or allow more efficient use of existing technology. This indirect channel is external to firms located at any point on the network. Unlike the first channel, they operate largely outside the market place and are not mediated by prices.

The role of infrastructure for development has been emphasized quite often in the developing economics literature (e.g. Hirschman, 1958). Low rural productivity and subsistence farming characterize many poor countries. The former partly relates to lack of access to local market, which in turn is correlated with lack of roads and other transport infrastructure. High transaction costs hinder optimal specialization and discourage investment, and contribute to stagnation in a low-level equilibrium trap. The existence of high-quality infrastructure may also affect firms' location decisions, where, for example, economies of scale and transportation costs are relevant components (e.g. Krugman, 1991).

Whereas the benefits of transport infrastructure in advanced economies often relate to the relief of congestion effects, in developing countries the benefits are primarily more rudimentary. For instance, one may conjecture that the importance of connecting two cities (e.g. Nairobi and Mombasa in Kenya) involves the ability of being able to transport people and goods between the cities rather than any congestion alleviation. Add to this the proven significance of providing feeder roads (Andersen, Japan).

Transport infrastructure brings down transportation costs and allows for larger factor and goods markets, more efficient distribution and reduced costs of moving goods from, for example, a farm or factory to retailers' shelves. Transport infrastructure increases the size of markets and producers cluster, which leads to specialization and economies of scale. Roads boost productivity by providing firms with lower distribution costs, facilitated by easier access to suppliers, intermediaries and other input markets, and proximity to a wider pool of consumers and final goods markets. Transport infrastructure also reduces adjustment costs of private investment, e.g., setting up of a new firm or factory.

More subtle, a connection between transport, organizational change and innovation can be made. New technologies take time to have an effect on productivity, partly because of lack of commercial applications. Sometimes complementary innovations are needed. Furthermore, replacing older machines with newer is not immediately profitable. This means that firms take time to make capital investments required to take full advantage of new technologies. Also need organizational changes and in business practices to achieve potential productivity, e.g., growing in size to take advantage of economies of scale provided by new technologies, such as railroad, which gave rise to factories.

Transportation infrastructure also impact on exports. Countries tend to export the goods for which they have a large domestic market (home-market effect) because with increasing returns and transport costs, there is an incentive to concentrate production close to its largest market; scale economies can be realized and at the same time by locating near the largest market transport costs are minimized. Roads and railways reduce transport costs and increase access to markets. Falling transport costs increase urbanization and agglomeration.

The scope for exploiting higher returns to scale from agglomeration externalities (e.g., access to large pool of workers and localized knowledge spillovers) is hampered by distance to major markets, both within and across countries, due to transportation costs. Such costs also reduce the scope for specialization according to comparative advantage (Boulhol, de Serres and Molnar, 2008).

Building transport infrastructure affects local land values, where productivity, accessibility and/or social amenity values for the locality are affected by the investment (Grimes and Liang, 2008). The reason is that firms and workers migrate to that land because of good infrastructure services. Roads can affect firms' location decisions by reducing output costs (e.g., costs associated with the amount of output reaching consumers), spurring vertical foreign direct investment (FDI) when multinationals base their location decisions primarily on costs, but providing a disincentive for horizontal FDI in regions with poor infrastructure.

Transport infrastructure is crucial also because it is a non-traded good, i.e., international trade cannot fix lacking roads. To the contrary, poor transport network will be exacerbate problems by reducing the scope for trade and their subsequent benefits.

Transport infrastructure is lumpy joint use networks with many different simultaneous users (club members) and uses. The conditions for optimal provision involve the summation of benefits across the different users, adjusted for congestion effects. The benefits associated with any one segment of the network depend on the size and configuration of the entire network and not just with that segment. Hence, spillover externalities between segments may be important. Furthermore, addition or expansion of key network effects can have a magnified effect throughout the network, so called "igniting effects" (Hulten, 2004, 2005).[3]

Morever, network externalities can arise from, for example, elimination of bottlenecks. Resulting lower transport costs can expand markets and lead to efficiency gains through, for example, economies of scale and scope, and increased competition. Also new and better technologies can become available or allow for improved efficiency in the use of existing technology. These are externalities because the effects are external to the firms on any point on the network. Unlike the first channel, this occurs outside the market place without price mediation (see Hulten, 2005, for an elaboration of these issues, and Hulten, Bennathan and

[3] See also Murphy, Schleifer and Vishny (1989) for an interesting discussion on the role of infrastructure (railroad) for industrialization and the Big Push. A point made is that a railroad is not built unless a sufficient number of sectors industrialize, which in turn cause firms to avoid committing to large-scale investments needed for industrialization.

Srinivasan, 2005, for an empirical application to Indian manufacturing). It is this second channel that exerts a positive effect on total factor productivity (TFP).[4]

Transport infrastructure caters for efficient allocation of resources, alas without for example roads labour input may be stuck in relatively unproductive activities. Poor roads imply that vehicles wear down much quicker, that is, their depreciation rate increases. Another benefit is the possibility of developing hinterland areas of a country—inland China constitutes an example.

The channels through which infrastructure influences TFP depend on factors such as type of infrastructure, context and aggregation level. In most countries, the public sector is responsible for provision of infrastructure, partly because of its (partial) public goods and natural monopoly characteristics (e.g. they facilitate many different economic activities), but also because they come in "large quantities" and thus are too expensive and to be funded by the private sector. Instead, funding comes via taxation, or in the case of many developing countries, via official development assistance. Another common characteristic is that they are lumpy in the sense of technical indivisibilities.

Transport infrastructure can also impact on health outcomes, which in turn affects productivity. Access to electricity reduces the cost of boiling water, while improving hygiene and health. In addition, hospitals are highly dependent on electricity. Transportation infrastructure increases access to healthcare and reduces the time away from work due to illness. A related channel relates to education. Better roads and sanitation allow children better access to education and raise school attendance. Electricity increases opportunities to use electronic equipment (e.g. computers) and study time, which improve learning. The effect on health and education are also interdependent in that better health increases school attendance and learning ability, and better education increase public awareness and capacity to address health needs. Studies that fail to account for these additional, or non-traditional, channels may actually end up *under*estimating the role of infrastructure (Agénor and Moreno-Dobson, 2000).

[4] On the other hand, unless bottlenecks are attended to congestion could be seen as representing a negative externality as the number of users increase.

2.2. Review of the empirical literature

The modern literature on infrastructure was sparked by Aschauer's (1989) paper on public capital and GDP growth in the United States.[5] The implication of his estimate was that an investment would pay for itself in less than two years. While some researchers (e.g., Munnell, 1992) found support for Aschauer's results, many others questioned them. For example, Gramlich (1994) in his review of the literature asked why, with such a large return, not everyone started investing in infrastructure. Others related the large estimate to questionable econometric practices. The large estimate could, for example, stem from failure to account for omitted state-dependent variables, reverse causality and endogeneity bias. The problem is that one may also obtain larger-than-expected estimates due to externalities and network effects and, in any case, it is difficult to know how large an estimate is acceptable.

An example that returns to transport infrastructure may be high is provided by Estache (2006), who, based on others' empirical work, reports the following expected returns to investment in roads, 200 per cent (or 80 per cent when outliers have been excluded). The role of infrastructure is to expand the productive capacity by increasing resources and enhancing the productivity of private capital.[6] Another channel is to raise the rate of investment, since the return to capital may increase when the productivity of private capital increases. However, although an increase in public capital formation normally leads to an increase in overall capital formation, it may also displace private capital formation through crowding out effects. Causality running from infrastructure to productivity can easily be envisaged. Yet, comparatively little attention has been paid to quantifying to effect of infrastructure on productivity.

Although such externalities are of extraordinary interest to isolate, it cannot be done in studies based on aggregate data. Actually, estimated elasticities are likely to be inflated by externality effects, which partly can explain why many studies seem to find very strong associations between infrastructure and economic performance. Unless one is interested in isolating externalities, this does not have to be a problem. However, the issue is in knowing that externalities and not some econometric problem is behind the strong result.

What will be made clear from the review is that many studies tend to zero in on one or two econometric issues and try to resolve them. Most of the studies focus on some aggregate, such

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[5] And later on cross-country samples of developing countries (Aschauer, 2000) and Mexico (Aschauer and Lachler, 1998).

[6] Because production factors are gross complements, a higher stock of infrastructure raise the productivity of other inputs.

as GDP growth and the proxy for infrastructure is often some monetary measure of public capital. However, few works directly measure physical transport infrastructure or attempt to explain industrial development, and even more seldom are papers relating both variables found. When it is found, the study only covers one country and either level or growth. In the review, only papers that use direct measures of transport infrastructure will be covered. The starting point is papers from the field of economic history.

In a historical (19^{th} century) study of European markets and integration, Keller and Shiue (2008) show the importance of new transportation technology on the size of the market. It is also shown that transport infrastructure dominates institutional change in terms of impact. The authors conclude that today's globalization and increased vertical disintegration of production too is positively influenced by lower transportation costs for intermediate products as well as advances in information and communications technologies.

Continuing on the transport revolution, Atack, Haines and Margo (2008) draw similar conclusions for the United States. As transportation infrastructure (railroad) spread and improved, the costs of shipping goods decreased. Market size increased and destroyed monopolies, while increased competition led firms to raise productivity through division of labour and mechanization. For example, factories replaced artisan shops and more workers specialized in production tasks were employed. Also, more subtly, transportation networks allowed for cheaper transporting of superior energy sources, such as steam engines and coal, and, thus, lowered the costs of adopting steam, which in turn led to more factories and more efficient production.

A related study by Atack, Bateman, Haines and Margo (2009) shows that the establishment of railroads caused half the urbanization in the American Midwest. The significance of this is that lower transport costs led to more trade, which, in turn, led to higher incomes and wages, increasing overall demand. Another element is that people tended to move to places where the railroad was heading, giving rise to new industry locations. Urbanization meant that production costs decreased and that economies of scale could be reaped, supporting agglomeration economics. Further support for this finding comes from Herrendorf, Schmitz Jr. and Teixeira (2009), who add that the large reduction in transportation costs induced convergence of regional per capita incomes. It can be concluded that, based on these studies, development of the railroad system has had a profound impact on industrialization in the United States.

On the issue of causality, Fernald (1999), using the Seemingly Unrelated Regression Estimator (SURE) is able to show that in the case of the United States, using industry data from 1953 to 1989, road network growth causes productivity growth and that the direction of causality does not run the other way around. It is, however, worth noting that the first new road network can have a very positive effect on productivity, whereas the marginal benefit of a second network would be small or even nil. This suggests that looking at the past returns may not be a good predictor for future ones.

Further evidence for developing countries is provided by Dethier, Hirn and Straub (2008), who survey the Business Climate Survey Data of the World Bank. For a group of poor or war torn economies they find that transport infrastructure is rated as an above average constraint in terms of explaining enterprise performance in developing countries. Andres et al (2008) provide further support along similar lines.

The impact of transport infrastructure is felt in terms of international competitiveness as well. When transportation costs fall, high-productivity exporting firms survive and grow, while low-productivity exporting firms are likely to fail. This reallocation raises aggregate productivity and produce non-traditional welfare gains from trade. The reason is that it is costly to export so only those firms that are already productive can overcome such costs and reap new exporting opportunities. Reductions in trade costs, thus, benefit large, productive, skill- and capital-intensive firms more because they export and import (Bernard, Jensen, Redding and Schott, 2007).

In a study on South Africa, Fedderke and Bogetic (2009) investigate several different measures of transport infrastructure, of which only those closest to the ones used in this study will be commented upon, in other words, kilometres of open railway lines, kilometres of total roads and kilometres of paved roads. Contrary to most studies reviewed here, the data they use are aggregate and three-digit manufacturing sector data. Since the present paper focuses on manufacturing, only results for the manufacturing sector will be reported. For the latter, the authors employ a panel data set in the estimation with observations from 1970 to 1993. In addition to single-equation non-instrumented estimators, the authors employ instrumental variables ones to correct for endogeneity bias and reverse causality. The authors distinguish between direct and indirect effects, where the former concerns labour productivity growth and the latter TFP growth, both based on value added production functions.

Without instrumentation, nearly all estimates are negatively signed. Generally, the instrumented elasticity of labour productivity with respect to transport infrastructure is higher than in the non-instrumented case, i.e., instrumentation tends to inflate the estimates, while the expectation might have been the opposite. The elasticity of railways, total roads and paved roads are, respectively, 0.81, 2.95 and 1.08, which seems excessive. In the case of TFP growth, the respective elasticities are 0.07 (statistically insignificant)[7], 2.80 and -0.45, suggesting that no general conclusion can be drawn regarding indirect effects. Because of some of the large point estimates obtained, as well as the wide range of estimates, it is difficult to draw conclusions from their study, except perhaps that transport infrastructure seems to matter for manufacturing growth.

Easterly and Rebelo (1993) is another study that uses instrumental variables estimation. Their sample includes some 100 countries for the time period of 1970 to 1988, with one observation per country and decade. After having collected and constructed new public investment data at aggregate and sectoral as well as different levels of government, and constructed decade-average public investment ratios, the authors regress decade-average per capita growth on this variable. The finding is that transport and communication investment is consistently positively correlated with a coefficient ranging from 0.59 to 0.66, which is large. The coefficient obtained for general government investment is, at 0.4, much smaller. By way of instrumentation to get at reverse causation, they find that the coefficient increases to 2, while the coefficient for general government investment is 0.7. Although the authors are disturbed by the size of the estimated coefficients and suggest that more work is needed, they conclude that causality runs from infrastructure to growth.

Devarajan, Swaroop and Zou (1996) develop a growth model to show that the composition of public expenditures ought to matter for growth, with the expectation being that capital expenditures such that infrastructure should be positive correlated with growth, while current expenditures may be negatively correlated. To this end, they use annual data on 43 developing countries from 1970 to 1990, estimated using OLS. By measuring the dependent variable, growth of real GDP per capita, with a five-year forward lag structure they hope to address the joint endogeneity of growth and public expenditures as well as reverse causality. They obtain the rather unexpected result that current expenditures increase the growth rate, while capital expenditures *reduce* the rate of growth. Similarly, using components of expenditures the coefficient on transport and communication is statistically significant and negative. Checking this result against a sample of 21 developed countries the conclusions are reversed and in line with a priori expectations. The same result sometimes applies to transport and

[7] Other measures of railway infrastructure used such as locomotives and carrying capacity are statistically significant, however.

communication, but seems to depend on the specification. The results, with the important exception of transport and communication, which is statistically insignificant, remain similar when using the fixed-effects estimator. The authors interpret the results to mean that governments in developing countries have been misallocating public expenditures in favour of capital resulting in an overprovision of such public capital and unproductive, at least at the margin.[8]

Using principal components analysis, Calderón and Servén (2004) for the time period 1960 to 2000 and 121 countries construct an infrastructure composite consisting of telecommunications, electricity-generating capacity and roads. In addition, they construct an indicator of infrastructure quality services based on waiting time for telephone main lines, percentage of transmission and distribution losses in the production of electricity and share of paved roads in total roads. They then regress growth of GDP per capita on a set of controls and the two infrastructure composites employing several estimators, including their preferred GMM-systems estimator of Blundell and Bond (1998). They also consider each of the infrastructures one by one. Independent of the estimator used, the stock of infrastructure enters significantly with a positively signed coefficient, while the quality composite is only significant in one case, but then with a clearly smaller parameter. Roads and roads and railways combined alone are also statistically significant, independent of specification, as well as when the quality of such services are included. However, in the latter case the quality of roads is not statistically significant.[9]

Canning and Pedroni (2004) apply panel cointegration techniques to test whether GDP per capita and paved roads per capita form a long-run relation and, if yes, in which direction causality runs. Their data cover 42 developed and developing countries between 1961 and 1990. They find support for cointegration and that causation runs in both directions. Furthermore, they find evidence of cross-country heterogeneity in terms of causality as well as regarding the sign of the long-run parameter. The observed heterogeneity suggests the need to also examine country groups, but in their paper this does not seem to alter their conclusions. Here, the issue of country groups will be revisited.

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[8] Using more advanced estimation methods and explicitly accounting for heterogeneity in public spending across 15 developing countries, Gregoriou and Ghosh (2009) essentially replicate the results of Devarajan et al (1996) for the time period 1972 to 1999. Most importantly, however, they show that the point estimate for capital and current spending, respectively, range from -0.56 to -1.18 and 1.18 to 17.32, both quite substantial.

[9] Calderón (2004) repeats the exercise for 93 countries for 1960-2005 for the composites of infrastructure stock and quality and essentially confirms the results of Calderón and Servén (2004a).

Another paper that takes seriously the issue of country-group heterogeneity is Hulten and Isaksson (2007). Using OLS and the fixed-effects estimators, the authors examine the impact of transport infrastructure on TFP levels across 112 countries for the time period of 1970 to 2000. In addition to full sample estimation, the authors also divide the sample according to income levels, or stage of development in their jargon. In addition, two other groups of countries are created, namely, Old Tigers, which refers to the first generation Asian fast-growers and New Tigers symbolizing the second and third generation. They suspect the impact differs across stages of development and it to be greater at relatively low levels of income and, possibly, for the fast-growers.

Concentrating on the panel-data estimator, they find that any road per capita, as opposed to paved roads, positively correlates with TFP for the sample as a whole. The parameter at 0.077 is not overly large. However, this is only true for the lowest and highest income categories, whereas for all the other groups the parameter is negative. This runs counter to the expected results, for which the parameter for the High Incomers was expected to be smaller than for all the other country groups. The impact of paved roads per capita is only slightly larger (0.103) than that of any road. Interestingly, the parameter is negative for all groups, except Lower- and Upper-mid Incomers and only statistically significant in the latter case. Railroad per capita is the third transport infrastructure considered and that enters with a coefficient of 0.134, with very large impacts recorded for both Tiger groups. The impact is also positive at the lowest income level and, with a small coefficient, at the highest income level. In other words, the kind of transport infrastructure matters greatly for TFP and differently so, although in unexpected fashion, at different stages of development. The issue of development stage seems important and is taken up in this paper as well.

Hulten (2005) summarizes two of his own studies on the U.S. and India, which both focus on the manufacturing sector in order to isolate the role of spillovers, or network externalities. His approach focuses on TFP rather than real output and sources from the work of Hulten and Schwab (e.g., 1991). These results are all based on census or survey data for manufacturing firms in the U.S. (1970-1986, Hulten and Schwab (2000)) and India (1972-1993, Hulten, Bennathan and Srinivasan (2003)). The measure of transport infrastructure is paved roads and the authors find that the rate of return of transport capital *externalities* increases from two per cent in 1974 to five per cent in 1993. However, when accounted for in a sources-of-growth framework, the effect is 25 per cent of total productivity, which is very large.[10] In the case of

[10] The term total productivity is used because the calculation is done within a gross output rather than value added framework.

the U.S., infrastructure is not statistically significant, but that is probably because interregional differences in total productivity levels are effectively zero, leaving nothing to be explained. Finally, the author surmises that the effect of infrastructure investment and attendant externalities depends on of well-developed the network is, where a larger effect is expected in a relatively undeveloped network.

Based on Barro (1990), Noriega and Fontenla (2005) develop a model for Mexico where public and private capital are complements. Evidence for the role of transport infrastructure (kilometres of roads) is then sought by way of time series econometrics—bivariate vector autoregression—and long-run derivatives, covering a time period of 1950 to 1994. The impulse-response analysis shows that shocks to transport infrastructure become positive and significant after eight years, i.e., it takes eight years before such infrastructure has a significant effect on real output per worker. For the time horizon of 20 years considered provision of roads services never becomes optimal. In other words, the impact of transport infrastructure, in the case of Mexico, only shows up after a rather long lag and a contemporaneous regression might not be able to capture the total effect.

Transport infrastructure also influences industrial development through other variables. For example, Castro, Regis and Saslavsky (2007) analyze foreign direct investment (FDI) inflows to Argentina. They find that paved roads, in particular, matter for the location of FDI. A 10 per cent increase in per capita paved roads increases FDI in the host province by between 17 and 33 per cent, while in geographically close provinces the effects in between 12 to 14 per cent. Similarly, Albarran, Carrasco and Holl (2009) show that transport costs reductions increase the probability of entry into exporting, while Limão and Venables (2001) demonstrate the importance of infrastructure for determining transport costs.

In sum, large estimates are generally obtained when regressing output or productivity on transport infrastructure. The issue does not so much seem to be whether transport infrastructure is important for growth, but why the estimated impact is so large. However, very few papers focus on industry or industrial development and only two of them address stages of development concerns. To these issues, the paper will now turn.

3. An empirical model of transport infrastructure and industry

Developing an empirical model for industry and transport infrastructure presents several challenges. If the model is based on what has come to be known as growth econometrics, then more than hundred candidate determinants present themselves. Such proliferation may be justifiable as a means to model complex matters, but is hardly tractable as an econometric model. Luckily, another strand of literature has developed in parallel. This literature relates to income levels and basically concerns so called deep determinants. These primarily include institutions (e.g., Acemoglu, Johnson and Robinson, 2005), geography (e.g., Sachs, 2003), human capital (Glaeser, LaPorta, López de Silanes and Schleifer, 2004) and international integration, often in the form of trade (e.g., Frankel and Romer, 1999). Together with agricultural labour productivity, which comes from the industry and structural change literature (e.g., Lewis, 1954; Hirschman, 1958) those deep determinants will provide the control variables in the empirical transport infrastructure and industry model. By calculating the changes of these variables over time, also an industrial development model is obtained and those are the two empirical models to be estimated.[11]

The role of agriculture in furthering industry is interesting and statistical links between the two sectors seem to be the norm rather than the exception. On the one hand, improved agricultural productivity can be viewed as releasing resources, especially labour input, to manufacturing. Jorgenson (1961) and Sachs (2008) state that without technological progress in the agricultural sector, a modern sector might not even prove viable. The argument is that only when agricultural productivity is high—implying that a farm family can feed many urban citizens so that not each resident has to feed itself—can a significant share of the population become urbanized and engage in manufacturing production. Agriculture could then be seen as *pushing* industrial development. However, if the migration leads to shortage in food production (forward linkages) or the two sectors' marginal productivities converge agricultural growth can constrain manufacturing growth (Fei and Ranis, 1961).

A sectoral link can also develop because manufacturing productivity exceeds that of agriculture and, therefore, *pulls* labour out of the latter sector. This view holds that the marginal productivity of labour in the leading modern sector (i.e., manufacturing) much higher than in the laggard one (i.e., agriculture). In fact, because of unlimited supply of labour in agriculture, the marginal productivity there is extremely low, if not negligible. Labour, therefore, has a wage incentive to migrate from agriculture to manufacturing, allowing the modern sector to further grow and develop the economy (Lewis, 1954). Whichever effect—push or pull—that dominates, the link between the sectors has to be accounted for.

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[11] Note that geography will not be explicitly accounted for, since it will be captured in the panel-data analysis by the country-specific effects.

There are additional reasons linking the two sectors. The agricultural sector's exports provide foreign exchange, which can be used to import material and capital goods to industry. Furthermore, with a functioning banking sector, successful agricultural savings can be channelled to and invested by industry. Redistribution of agricultural surplus can be taxed and provided as support to manufacturing. Industrialization also raises demand for agricultural goods (Johnston and Mellor, 1961).

Agriculture is also a client of manufacturing. For example, fertilizers are important inputs in agricultural production so backward linkages are thus important. A slow-growing agricultural sector can, therefore, act as a drag on manufacturing. The expected estimated coefficient, hence, is not unequivocally positive. [12] That agricultural performance and industrial development are linked should be beyond doubt, but it is neither the purpose of this paper to sort out the causal direction of the link, nor whether that link is positive or negative.

There are several reasons to expect human capital to enter with a positively signed coefficient. For example, increased human capital leads to improved productivity, both in sectors and overall. It allows for operating more complicated tasks and producing outputs that are "high-skill". Human capital could also imply positive externalities along the lines of Lucas (1988). Foreign direct investments (FDI) tend to locate in human capital rich places. Benefiting from FDI knowledge externalities and technology transfer requires that domestic firms have sufficiently high human capital levels, i.e., absorptive capacity. Widespread human capital will also increase the scope that new technologies are, in the words of Basu and Weil (1998), appropriate. Industries unable to learn, adopt and adapt new techniques and technologies will be unable to move up value chains.

It is also clear from a massive amount of work that institutions and their quality play a role for development. Institutions reduce the uncertainty of economic interaction, increasing market efficiency and promoting long-term large investments (North, 1990). This also applies to the case for industry. For example, Rodrik *et al* (1994) discuss how institutions can create incentives that lead to innovation and new technologies. Much of such activities is intrinsic to

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[12] Based on a multivariate causality framework in a panel setting, Awokuse (2009) is able to establish strong evidence supporting the notion that agriculture is an engine of economic growth, thus suggesting that agricultural labour productivity should be causing manufacturing performance. See also Pinstrup-Andersen and Shimokawa (2006) for reasons why agriculture could be a driver of growth. The same paper discusses how insufficient infrastructure is one of the key bottlenecks for utilization of agricultural research and technology by limiting farmers' options and agricultural output. With good rural infrastructure, economic returns to research and technology tend to be high. By contrast, Alvarez-Cuadrado and Poschke (2009) find evidence in support of manufacturing-led structural transformation.

manufacturing production and drives industrial development and, thus, increases the contribution of industry to aggregate productivity performance. Investments in transport infrastructure are large, lumpy and sunk. As such, and to the extent that such investments are carried out by private investors and unless ownership of property used as collateral can be secured, incentives to invest will be thwarted and investment held back. Institutional quality is, therefore, likely to have an impact on industrial development as well as on the amount of railway and roads.[13]To this end, impartiality of courts is crucial. The role of institutions for industrialization is highlighted in, for example, Botta's (2009) model on structural change and economic growth.

Jones (2008) discusses how corruption that leads to poor transport infrastructure reduce output in all affected sectors, including construction. Declining output in construction, in turn, reduce the output of transport infrastructure. Thus, there are important knock-on effects on further development of such capacity. Jones calls this a multiplier effect. This is true for other complementary inputs as well, but not all of them are equally important to deal with in terms of their damaging effects on production. And the more sectors that are linked to the transport network, the more important it is for overall output and development. In developing countries many things at the same time tend to be fraught with problems, and transport infrastructure is often one of those.

International integration is hypothesized to exert a positive impact on industrial development. Small domestic markets hold back industry in many developing countries. Opening up to trade and creating exports opportunities offers scale effects. This can, for example, come about by being able to lower unit costs of material by buying large amounts or producing at minimum efficient scale. Although the evidence is limited, there seems to be some scope for learning from exporting, at least for low-income countries (Bernard et al, 2007). Furthermore, competing with foreign producers may force domestic firms to become more efficient. Working with customers in industrialized countries may also give rise to knowledge externalities. Earning foreign exchange also means increased ability to import capital goods and materials from abroad at international prices that may be lower than those offered at home.

Finally, countries without a coastline or sea navigable rivers, and location in the tropics or in disease-stricken areas, find it relatively difficult to develop. The direct impact on industrial

[13] An example of this connection, and running over politics, is suggested by North and Weingast (1989) and finds empirical support in Bogart (2009).

development is probably smaller than on agriculture. However, industry suffers indirectly through its linkages with agriculture and unfortunate geographical location may, therefore, hamper industrial development. Geography, through proximity to buyers, also affects exports in that the longer the distance, the smaller the export opportunity.

3.1. The perils of modelling infrastructure and industry

Previous work on infrastructure and economic performance has been criticized for its econometric flaws. The most common critique levelled on the infrastructure literature is that the estimated impacts have been way too large. Notwithstanding large estimates, it is not always clear in which direction causality runs. Overestimation may have several sources. Examples of such sources include endogenous bias of infrastructure, reverse causality and omitted state-dependent variables, such as geography, which are correlated with infrastructure.

It may be useful to focus a little on the large estimates commonly observed in the literature. First of all, because of sectoral linkages and multiplier effects it is difficult to know a priori the “appropriate” size of the estimated impact. For example, and as was argued above, distortions to the transportation sector reduce the output of many other sectors including truck manufacturing and the fuel sector. This in turn will reduce the output in the transportation sectors. There is thus an amplification force because of intermediate goods and multipliers (Jones, 2008).

Another difficulty concerns the stock of transport infrastructure versus the purpose of such infrastructure. In former colonies, roads and railways were often built to transport minerals and other natural resources for further shipment to Europe. Hence, the networks do not necessarily and optimally serve the present society and industry. In Africa, maintenance has been lagging behind, and even been ignored, resulting in few operational locomotives and large amount of unusable rail. Roads are often plagued by numerous potholes and overall poor quality, making travelling and transporting hazardous.

Continuing on Africa, Foster (2008) argues that the road density in the continent is sparse when viewed against the vastness of the continent; only one-third of those living in rural areas are within two kilometres of an all season road, compared with two-thirds in other developing regions. This implies very low intraregional connectivity in Africa, measured in terms of transcontinental highway links or power interconnectors. The relevance for the discussion here is that the measured stock of transport infrastructure may actually be smaller and less useful than data might suggest. If new infrastructure investments create positive spillover effects in neighbouring areas total positive regional infrastructure effects may in reality be higher than what is reported.

But there are possible negative feedbacks as well. For example, investment in highways can increase the demand for highway use, leading to congestion, which in turn lowers productivity by having an impact on labour.

Also the composition of public capital may matter. For example, in a road network, the marginal productivity of one link depends on the capacity and configuration of all links in the network. The consequence could be that only able the average effect, and not marginal effect, is estimated. Historical rate of returns can be high if the estimates capture the effect of increasing the network of public roads that may generate significant externalities. However, this is only true for the first network; replication may have a very low marginal return (Fernald, 1999). This argument is in line with the notion of diminishing returns. The implication is that low-income countries with small transport infrastructure stocks ought to enjoy higher returns to investment in such infrastructure than will high-income counterparts.

4. Econometric modelling strategy

The econometric model has to address a number of issues raised in the literature. These include spurious correlation due to nonstationary data, omitted state-dependent variables, endogeneity bias and reverse causality, of which the latter three may all cause overestimation and will, therefore, receive particular attention in this paper.

On the issue of spurious correlation, Hulten and Schwab (1991) estimate the relation between TFP and infrastructure using first differences. While applying first differences addresses nonstationarity in the data, it also removes the long-run relation between the variables of interest. More specifically, instead of estimating the impact of increasing the stock of infrastructure on, for example, manufacturing, it is the impact of increasing the growth rate of infrastructure on TFP growth that gets estimated. In other words, the analysis shifts from levels and long-term to one of growth and short-term. Unfortunately, there is no reason to believe that the short-term impact should be the same as that in the long-term. A better solution, which also preserves the long-run information of the data, is that of Canning and Pedroni (2004), who apply panel cointegration techniques and establish a long-run relation between infrastructure and income per capita. Their finding of cointegration will be assumed to hold in this paper as well.

To address omitted state-dependent variables, some researchers, for example Holtz-Eakin (1994), have used panel-data estimation techniques, such as the Fixed-effects (FE) estimator.[14] The country-specific effects can be interpreted as omitted initial conditions, for example the initial stock of infrastructure or, more generally, as a way to account for the initial development level. Furthermore, the country-specific effects capture omitted state variables, such as geography and cultural traits.

The advantage of the FE estimator is that it can handle the issue of omitted variables that may be correlated with infrastructure. Failing to do so will affect the estimated coefficient. To some extent, FE also helps mitigate the adverse consequences of endogeneity bias. For example, because public investment in transport infrastructure is likely to be tax-financed, richer countries tend to have bigger infrastructure stocks. An example is foreign aid used to finance public investment, which is allocated predominantly to the poorest developing countries.

But there is a problem with the FE estimator, namely, that it only accounts for the within country variation. As such, it ignores statistical variation between units, which, in some cases, may be the most relevant. Furthermore, it is not clear to what extent public capital varies over time within countries. This provides a rationale for the Random-effects (RE) estimator. However, it should be noted that the potentially implausible assumption of zero correlation between explanatory variables and the country-specific effects may render the estimate biased.

With these issues in mind, this paper attempts to account for both between and within variation by employing both the FE and RE estimators. Endogeneity bias and reverse causality are dealt with by application of instrumental variables (IV) versions of FE and RE. All estimation methods are applied to both levels and growth regressions.

[14] To some extent, this estimation method addresses nonstationarity as well, since, in the within form, deviations from the mean are used.

The regression analysis commences with an OLS benchmark estimation:

$$MVApc_{it} = \beta' X_{it} + \lambda' Z_{it} + \varepsilon_{it} \,, \tag{1}$$

where X is a vector including agricultural labour productivity, manufacturing exports per capita, human capital and institutions, and Z is a vector of transport infrastructure and ε is the standard i.i.d. residual. The FE and RE counterpart of (1) yields:

$$MVApc_{it} = \beta' X_{it} + \lambda' Z_{it} + \eta_i + \varepsilon_{it} \,, \tag{2}$$

where the additional parameters η_i represent unobserved country-specific effects, be they fixed or random.

In the IV versions of (2), the possibility that infrastructure Z_{it} is endogenous and causality running in the "wrong" direction are acknowledged and addressed. The instrumentation of infrastructure is meant to address these two issues. The vector Z_{it} is then replaced with the fitted counterpart $\tilde{z}_{it}$

$$MVApc_{it} = \beta' X_{it} + \delta' \tilde{z}_{it} + \eta_i + \varepsilon_{it} \,. \tag{3}$$

The instrument vector I_{it} includes external variables proposed and found reasonable by Canning (1998). The external instruments are lags 1-3 of population size and urban population density, and the growth of these variables. There are also internal instruments, namely, the other assumed exogenous explanatory variables X_{it}. Again, lags 1-3 are used. In addition, in the levels regression lags 1-3 of transport infrastructure growth is included, whereas in the growth regression, lags 1-3 of the transport infrastructure level replaces its growth counterpart. Admittedly, the choice of lag length is entirely arbitrary, but is kept low to preserve degrees of freedom.

Unfortunately, it is possible to argue that some of the external instruments chosen are correlated with manufacturing growth. For example, structural transformation often goes hand in hand with both manufacturing growth *and* urbanization. However, the level of urbanization or population should not present such a problem in the FE estimation, since the country-specific effects presumably accounts for that. Population growth and the rate of urbanization should also to a lesser extent be correlated with the *level* of manufacturing, although one may conceive of a situation where relatively rich countries have a slower growing population *and* high manufacturing per capita.

Easterly (2009) argues population size is not necessarily a bad instrument because there is a small-country bias in foreign aid such that smaller countries receive more aid on a per capita basis as well as higher aid as a ratio to their income. Because aid is often used to fund large infrastructure projects in developing countries, at least for IV-regressions involving such countries population size might actually work well. Furthermore, Easterly also claims that the literature has been unable to show that population has any scale effect for economic growth—for which manufacturing ought to be significantly important—which gives some additional support for using population as an instrument.

The final instrument vector is decided through a sequence of tests. In the first step, all instruments and their three lags are included in a regression. The error from this regression is then included in a second step regression to test for its statistical significance using a simple T-test. If the error term is statistically significant at conventional levels, infrastructure is deemed endogenous. To decide whether an instrument is valid, each variable in turn is tested, where statistical significance occurs at a T-value of at least 3.30. In addition, lags 1-3 of each variable are jointly tested—for example, lags 1-3 of population size—as is all lags of each variable, for example, the first lag of all instruments. In this case, the F-value needs to exceed 10 (Hill, Griffith and Lim, 2008). In each step the vector of instruments is tested using Sargan's over-identifying test, since too many instruments may overfit endogenous variables.

If, in the first step, the residual is statistically insignificant *and* none of the T- and F-test is statistically significant, the test process stops and infrastructure is deemed exogenous. However, to be sure no mistake has been made—after all there are strong priors that infrastructure is endogenous—a biased view against infrastructure being exogenous is introduced. This is done by continuing the test procedure with those variables that are statistically significant at conventional levels, but have T-values below 3.30. It turns there are only a few cases when the original test procedure erroneously leads to the conclusion of exogeneity, but when that occurs infrastructure is taken to be endogenous. Finally, it is ensured in the first stage regression that the instruments chosen indeed all are statistically significant.

Equations (1) to (3) are estimated in levels and first difference form to answer whether the level and growth of transport infrastructure help explain cross-country differences in manufacturing levels and rates of industrial development.[15]

5. Data

Data on manufacturing value added per capita (MVA) in constant US$ 2000 are drawn from UNIDO's World Productivity Database (Isaksson, 2010). Variables for transport infrastructure come in several shapes and forms and source from Canning (1995, 1998). Unlike other kinds of infrastructure, it is less clear with which variable to scale transport infrastructure. Canning's (1998) work suggests that transport and population are strongly correlated, however with less than one-to-one (the estimated parameter of 0.8 is fairly close to unity, however). This makes scaling by population size somewhat unsatisfactory and for that reason land area is used as well. And after all, transport infrastructure are meant to transport people and goods across land area and the larger the country—not necessarily the economy—the larger the road or railroad network.

This means there will be two measures for each transport infrastructure. The first set of two is road per capita (ROADPC) and road per land area (ROADPA), which essentially means any, or total, road, paved or unpaved. Paved road is used to proxy for the quality of any road (RDQLPC and RDQLPA, respectively).[16] Finally, for railroad (RAILPC and RAILPA) there is no quality adjustment. All transport infrastructures are measured in kilometres. Extrapolation of Canning's data is based on Calderón and Servén (2004).[17]

Human capital (H) is measured as the average attainment level for the population aged 15 and older (Barro and Lee, 2000). Institutions (INST), proxied by economic freedom, is supplied

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[15] In the case of first differences, the issue of nonstationarity disappears unless the data have two roots. Although this could be the case for the fast-growers for *some* period of time, on average this does not seem to be a major issue.

[16] It is questionable how far a measure of paved roads goes in terms of measuring quality adjustment. Lack of maintenance reduces the quality and, thus, lifetime of roads in a significant way (for a discussion, see, for example, the World Bank (1994)).

[17] There are at least two reasons why physical measures of infrastructure are to be preferred to monetary measures. Pritchett (1996) argues that the (monetary) value of public investment may contain little information regarding the efficiency in implementing investment projects, especially in developing countries. According to his estimates, only about little more than half the investment makes a contribution to the stock of public capital. Consequently, public capital stocks are likely to be overestimated, which may affect the estimated impact of it. Furthermore, if the composition of the stock matters because the marginal productivity of one link depends on the capacity and configuration of all links in the network, it is not clear whether it is the average or marginal product of additional roads, telephone lines or electricity-generating capacity today that is being measured (Fernald, 1999). These issues may be useful to bear in mind during the analysis.

by Gwartney, Lawson and Emerick (2003), while agricultural labour productivity (AGR) and manufacturing exports (MEXP), the latter two explanatory variables in constant US$ 2000 are obtained from the World Development Indicators (2007). As has already been indicated, geography is captured by country-specific effects.

These data cover 79 advanced and developing countries, which have data on road infrastructure, while the corresponding number of countries in the case of railroad is 77. The actual number of observations used in the estimations is a function of the combined data availability of all the right-hand side variables and instruments remaining in the final specification. The panel is unbalanced in the sense that some countries are observed for shorter time periods.

In order to analyze whether a country's stage of development matters for the role that infrastructure plays, the countries are grouped according to their year 2000 income levels—High, Upper-Mid, Lower-Mid and Low—but with a special group consisting of fast-growing Asian countries, for simplicity called Tigers. These groups are, henceforth, termed meta-countries. The latter group of countries may be of particular interest for their ability to sustain good economic growth for an extended period of time. And the question asked is, did infrastructure investment have anything to do with that growth? For the level, or long-term, analysis annual data in logs are used. The industrial development part of the paper uses the first difference of those data and hence pertains to short-term variations in growth. Table 1 shows the list of countries in the dataset grouped according to their meta-country belonging.

Table 2 contains a collection of summary statistics for the entire sample. It is readily seen that the range of railroad infrastructure across countries, however scaled, is large, as is quality-adjusted road per land area. The range for the other transport infrastructures is significantly large too, but perhaps more in line with that of manufacturing value added per capita. Although this does not necessarily imply a correlation between the two, this is, indeed, the working hypothesis of this paper. The range of agricultural productivity and manufacturing exports is also significant, while those of human capital and institutions appear to be less so.

The range of growth rates start from the negative territory and continues to fairly high levels, e.g., 10.1 per cent for manufacturing value added per capita. The highest mean growth rate occurs for quality-adjusted roads per land area (2.7 per cent per annum), closely followed by manufacturing exports and agricultural labour productivity (both at 2.6 per cent). Manufacturing growth averages 2.4 per cent across countries and time. Two negative appearances should be noted as well. Those are RAILPC and ROADPC, implying that population growth outpaces that of transport infrastructure; RDQLPC grows slightly faster than population. It is also notable how, on average, little investment seems to be directed to railroad infrastructure. However, because land area is fixed, growth of infrastructure scaled using that variable is not negative. Generally, the quality of transport infrastructure improves at a faster rate than does the infrastructure itself.

Ratios between stocks of infrastructure across meta-countries add fuel to the notion of performance gaps between industrialized and non-industrialized countries (Table 3).[18] All groups significantly fall short relative to the High incomers' manufacturing levels, with the Upper-mid incomers coming closest at 14.84 per cent. As expected, the worst case is the Low-income meta-country, which only attains just over one per cent. In the case of RAILPC, Upper-mid reaches a little over 54 per cent of the High-income group's score, followed by the Low incomers at 18 per cent, Lower-mid at almost 15 per cent and Tigers at 12.28 per cent.

Changing to RAILPA, the picture alters significantly. Now, among developing countries Tigers take the lead at 52.5 per cent and are followed by Upper-mid, Low and Lower-mid at, respectively, 40.74, 14.68 and 12.43 per cent. The reason for the relatively good performance of the Tigers in this respect is, of course, that some of them are small in terms of land area—implying a small scale variable—but have large populations, that is, a large scale variable. It is also notable that Low incomers have more railroad than those at the next level of income.

All the road categories follow similar patterns, although Lower-mid Incomers now score higher than their Low-income counterparts. However, it is notable how the ratios fall when moving from total roads to paved roads. In this respect, Low incomers score strikingly low. Despite these rather depressing snapshot figures, some comfort may be found in the work of Yepes, Pierce and Foster (2009), which suggests that convergence in infrastructure may be underway.

The Annex contains two sets of two-way illustrations: the first for levels and the second for growth. A casual look at the levels illustrations suggests positive correlations between transport infrastructure, however measured, and manufacturing. This is also the case for the control variables, although in the case of INST the slope is less pronounced. The growth illustrations are more difficult to decipher. However, accumulation of human capital and agricultural productivity growth are positively related to industrial development, while change

[18] The story is reminiscent of those in UNCTAD's LDC report (2006) and World Bank's World Development Report (1994). The former adds that also the quality of infrastructure is remarkably lower in developing countries and, in particular, in LDCs.

in manufacturing exports and institutions appear flat. It also seems clear that RDQLPC and RDQLPA will be positively correlated with industrial development, while for RAIL and ROAD the variation could be too small to show up significantly in cross-country regressions.

Multivariate regression analysis will sort out whether these two-way relations will continue to hold or whether they also capture other features shared by other relations.

6. Regression analysis

There are two major sets of results to present. The first set concerns explanation of cross-country differences in manufacturing per capita levels. In other words, why do some countries have higher manufacturing levels than others? In the second set of results, the enquiry concerns why some countries' industries grow faster than others'. Both sets of results start by analyzing pooled datasets, and are followed by results based on meta-countries.

6.1. Manufacturing per capita

6.1.1. All countries

Tables 4-6 contain the results of three estimators, Ordinary Least Squares (OLS), Random-effects (RE) and Fixed-effects (FE). OLS, which is based on pooling the data, is the benchmark estimation, while RE and FE estimators, both panel-data estimators, are used to control for omitted country-specific effects (e.g., geographical features). The latter estimator also accounts for correlations between such effects and infrastructure as well as with other explanatory variables, while the former assumes away such correlations. In contrast to OLS, the focus of the FE estimator is on the within-effects, that is, the impact within, in this case, countries. However, removing between-country effects reduces the variation in the data and could render estimated parameters statistically insignificant. The rationale for employing the RE estimator in addition to FE, despite its obvious shortcomings regarding zero correlation between country-specific effects and right-hand side variables, is that it weighs in between-country variation, which is ignored by FE. Although fixed effects can mitigate endogeneity bias, the obvious objection of infrastructure being endogenous is more seriously addressed below.

To the vector of control variables—AGR, MEXP, INST, H—a trend variable (T) is added, which is meant to capture technological change common to all countries.[19] Because infrastructure is expected to have profound long-term effects on technological change, the trend variable enters in interaction with the six transport infrastructure variables (TINT). A simple interpretation of TINT would be to understand it as an indication of how the impact of transport infrastructure has changed over time. A more interesting one is that infrastructure strengthens/weakens the effect of technological change on manufacturing or alternatively, the incidence of technological change affects the impact of transport infrastructure on manufacturing. Whichever the case, the expected sign of the coefficient is positive.

Starting with the pooled estimator (Table 4) and railway infrastructure, the coefficient of RAILPC is positive and statistically significant at the 10 per cent level. The implication of the point estimate is that a 10 per cent increase of railway infrastructure per capita is associated with nearly half a per cent increase in manufacturing per capita. The total impact when accounting for the interaction term increases to 1.5 per cent. Either way, this effect is not particularly large. The sign of the coefficient seems to depend on the scale variable in that the coefficient of RAILPA is negative and statistically insignificant, however with a positive total impact.

With an estimate of 0.125 and a total impact of 0.22, road infrastructure per capita has a considerably larger impact than its railway counterpart. However, adjusted for quality, its total impact shrinks to near zero. When the scale variable is land area, road infrastructure is no longer statistically significant and the total impact just barely stays on the positive side.

The coefficients of the control variables are surprisingly stable across the transport infrastructure variables. The largest elasticities are those for agricultural labour productivity and human capital, which display elasticities of between 0.77 and 0.79 for the former and 0.69 and 0.76 in the case of the latter. Also INST and MEXP enter with the expected positive effects. The point estimates for INST range from 0.29 to 0.38, while those of MEXP are smaller, 0.104 to 0.133. Finally, overall technological change appears to have been negative for manufacturing. This may reflect the poor performance of many developing countries, which may dominate the average picture. These are the benchmark results to which the panel-data results will be contrasted.

[19] Clearly, the trend variable might, more generally, include the impact of macroeconomic environment or factors that affect trend changes in this environment. However, since technological change is interpreted to be one of the main factors behind such change, the interpretation of technological change will be maintained.

Some of these results may confound the effects of country-specific effects and those of the explanatory variables. Controlling for such effects dramatically change the impact of several of the determinants, clearly suggesting that the country-specific effects are correlated with omitted state-dependent factors, such as geography, as well as initial conditions, such as high or low income. Interestingly, the RE (Table 5) and FE (Table 6) estimators deliver fairly similar results, indicating that neither correlation between determinants and country-specific effects, nor between variation, is a major issue. Because of this similarity, the focus here is on Table 6.

What is the effect of moving from OLS to the fixed-effects estimator? Controlling for country-specific effects increases the coefficient of RAILPC from 0.047 to 0.209 and the total impact from 0.015 to 0.113. A 10 per cent increase of RAILPC is, thus, associated with a total effect of 1.1 per cent increase in manufacturing. This is a substantial increase compared with OLS and suggests that investing in railway infrastructure is important for industry. But changing scale variable to land area produces a statistically insignificant total impact, albeit positively signed. Hence, the result for railway infrastructure is not unequivocally positive.

Unambiguous is, however, the impact of road infrastructure. While the point estimate of ROADPC at 0.53 is larger than that for ROADPA (0.40), the total effects are reversed in order (0.40 versus 0.50). A 10 per cent increase of the road network is, thus, associated with an increase of manufacturing of between four and five per cent. In either case, there is little doubt that roads have had a sizeable impact of the level of manufacturing. It is also clear that the fixed effects results rather inflate than deflate the OLS estimates, suggesting that the country-specific effects could actually be negatively correlated with the explanatory variables. This could happen, for example, if the fixed effects capture initial income and there is convergence. The effects of RDQLPC and RDQLPA are at 0.68 (total effect is 0.60) and 0.58 (0.65) even larger. This means that the quality of roads has an additional effect on industry, but that the main effect comes from having a road network, be it paved or not.

Also the control variables are affected by the change of estimator. First, the stability of the estimates across transport infrastructure variables shown using OLS is gone. The explanation could be that the country-specific effects are correlated to different degrees with transport infrastructure as well as with the controls. Second, the parameters are generally lower, perhaps suggesting correlation with the country-specific effects. Third, INST is not longer statistically significant in any regression. The explanation is that in the OLS, INST may have captured some initial conditions such as initial income. In other words, industrialized countries also have good institutions, while countries in the lowest income category are also likely to have less functioning institutions.

Agricultural labour productivity is still statistically significant throughout, but the parameter is higher when population is used as the scale variable for transport infrastructure—for OLS the scale variable did not matter—and it now ranges from a low 0.28 to a high 0.65. Human capital has higher parameters when land area is used to scale transport infrastructure and the parameters are much higher in the railway regressions, but are statistically significant in all cases. Also manufacturing exports maintain its positive impact but now the parameter is only half the size and sometimes not even that. In fact, increasing MEXP by 10 per cent is associated only with less than a one per cent increase of manufacturing. This is much smaller than for the other variables involved.

So far, a large impact of transport infrastructure on manufacturing has been recorded. But, how much of this effect reflects causality running from railways and roads to manufacturing? To address this issue, all indicators of transport infrastructure are assumed to be endogenous. Two panel-data estimators are employed, namely, the RE and FE instrumental-variables estimators, RE-IV and FE-IV.

Tables 7 and 8 contain the results of the IV estimators. Once more the results of RE-IV and FE-IV are sufficiently similar to focus on one of the Tables only (Table 8). The coefficients of RAILPC and RAILPA climb significantly to 1.27 (1.04) and 0.37 (0.41), with the latter implying a change of sign. In the case of RAILPC there is no statistical support that railway infrastructure is endogenous. There is no longer any doubt that increasing railway infrastructure not only is associated with, but also will *lead* to an increase of manufacturing per capita. However, the magnitude depends greatly on the scale variable, but even selecting land area produces a sizeable effect. A conservative choice—RAILPA which is also deemed endogenous—leads to the conclusion that a 10 per cent increase of railway infrastructure provokes an increase in manufacturing of four per cent.

While the FE-IV estimator strengthens the impact of railway infrastructure, it has the opposite effect on roads. The parameters decrease and are, when population is the scale variable, imprecisely estimated. It is still the case the paved roads have a larger parameter, but this time it is twice as large; the difference between the total effects is smaller. Incidentally, it is only ROADPC and ROADPA that are statistically endogenous.

The conclusion is that railways indeed are important for explaining manufacturing levels, while for road infrastructure the conclusion depends on the scale variable. Generally, it can still be concluded that transport infrastructure matters for industry. Turning to the control determinants, they more or less retain their previous estimates, although for human capital the parameters have fallen somewhat.

6.1.2. Meta-countries

One wonders if these "average" results hold up across different stages of development. If yes, it would mean that investing in transport infrastructure is worthwhile for all developing countries. Recall that the expectation is that the marginal effect of an investment in a low-income country is larger than that in a high-income one. It should be noted at the outset that the two normalization variables—population and land area—give different implications. Effectively it is a comparison of changing transport infrastructure divided by also changing population with transport infrastructure divided by unchanging land area, where the latter ratio tends to always increase. These two variables are then associated with manufacturing, which is divided by population. The transport variable will thus grow faster than the other two, since there is no normalization variable to hold it back. This should be borne in mind when ranking the meta-countries, which, as will be seen, will line up very differently.

Table 9, which has one panel for each type of transport infrastructure, provides the results for the different estimators discussed above. Due to space limitations, only the coefficients relevant for transport infrastructure are presented. Empty slots mean that infrastructure was not endogenous.

Before analyzing the results, it needs to be noted that there are two ways to interpret the coefficients. The first, and the one needed here, is the actual value of the parameter independent of whether it is statistically significant or not. The interest here is which country group that has the largest point estimates and not whether transport infrastructure is able to explain differing manufacturing levels within a meta-country. One simple reason for the parameter to be statistically insignificant, while still being economically significant, is that countries in a group may be too homogenous, i.e., there is not enough variation within the group. The obvious trap involved in focusing solely on the point estimate is that it cannot be statistically separated from zero and the reader should bear this risk in mind. However, at the same time the implication is not necessarily that the point estimate is zero. For completion then, the second interpretation, as has already been alluded to, concerns whether the parameter is significantly different from zero.

It is, again, striking how the scale variable matters for how RAILPC and RAILPA impact on manufacturing. In the case of RAILPC, the largest total impact (0.23 in the case of OLS) occurs for Low incomers, which is in line with expectations. The impact is negative but close to zero for all other income groups.[20] For the Tigers, the total effect is -0.39 because of a large negative interaction term. The fixed-effects estimator, on the other hand, delivers a slightly larger than one-to-one total effect for the Tigers, while that for Low incomers turns negative. This result seems an exception because the RE-IV estimator restores the order.[21] All in all, the impact is largest for the poorest economies (Low and Lower-mid) and the fastest growing ones and slightly negative for the two highest income groups. This seems to be somewhat in line with the World Bank (1994), which shows how the share of railways in total infrastructure diminishes as income increases. In terms of parameter significance, for Lower-mid and Upper-mid incomers the estimates are always insignificant.

As already hinted at, the results for RAILPA are somewhat different. It turns out that the impact is still most important for Lower-mid and Tiger economies (based on FE-IV), while in the case of Low incomers, as well as the others, the impact is negative. This calls into question the RE-IV result for the Low incomers in the case of RAILPC and it might be that railway infrastructure is actually overprovided not only in the highest income categories, but also in the lowest. The reason for such overprovision could be foreign aid (see, for example, Devarajan et al, 1996).

Turning to roads infrastructure (ROADPC) and non-IV estimators, there is no significant difference in total impact between Low, Lower-mid and Upper-mid incomers, who all hover between 0.22 and 0.28. Investing in such infrastructure in the cases of the Tigers and High incomers, however, seems counterproductive. The impact for ROADPA increases to 0.58 for the Low incomers and the FE estimator, while for the others there is no change. This means that roads are most important at the lowest income level, at least when using land area as a normalization variable.

For ROADPC, invoking the results provided by the IV estimators better lines up the meta-countries so that the total impact falls as income increases. In addition, the fourth largest effect now occurs for the fast-growing Asian economies. For ROADPA a drastically different

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[20] In terms of statistically significant OLS parameters, only Low and High (-0.10) incomers are relevant.

[21] However, if the country-specific effects and explanatory variables are correlated and this, instead of the importance of accounting for between-country variation, is the reason for differing results, the RE-IV estimate is biased and the one based on the FE estimator is to be preferred.

picture is painted in that the largest total impacts are recorded for Low and Upper-mid, followed by High and Lower-mid incomers. This is unexpected and delivers different policy implications. Again, it boils down to a comparison of road infrastructure per person versus per land area.

The Tiger economies enjoy the greatest (total) benefit from paved roads (RDQLPC), followed by the two lowest income groups and then two highest in descending order. The effect of the FE-IV estimator is to single out the low-income group, while the RE-IV produces are very large impact for the high incomers. The preference is to believe in FE-IV rather than the RE-IV, but it has to be acknowledged that between effects may be important. For RDQLPA and FE, again the Low incomers score highest, followed by the Tigers, Lower-mid, Upper-mid and, finally, the High-income group. This order is maintained also under FE-IV.

It, thus, seems fair to conclude that, on the whole, the largest impact of road infrastructure occurs in countries with a relatively small initial stock and low income. As the income increases, the marginal impact declines. For railway infrastructure there are indications of overprovision.

6.2. Growth of Manufacturing per capita

6.2.1. All countries

The industrial development regressions are no different, except that all variables are now in log first differences. Tables 10-12 present the OLS, RE and FE results for growth of transport infrastructure. As with the level results, RE and FE produce consistent results and it suffices to comment on. Table 12, which is based on the FE results. Before doing that, the OLS results are worth analyzing (Table 10). The impact of increasing the growth of railway infrastructure is positive for industrial development, although the coefficient is not statistically significant. Road infrastructure, however measured, is positively and significantly related to industrial development. A percentage point increase in the growth of ROADPC raises the speed of industrialization by nearly 0.3 percentage points (from 3.6 to 3.9 per cent). Adjusting for quality does not change the impact much. For example, the corresponding total effect of RDQLPA is 0.23 percentage points. These are all economically meaningful impacts, but still within reason. Regarding the control variables, it can be reported that ΔH and ΔAGR are consistently positively related with coefficients of about, respectively, 0.42 and 0.14, respectively. Neither ΔMEXP nor ΔINST is statistically significant.

The effect of invoking panel-data analysis is to reduce the strength of several of the relations (Table 12). Railway infrastructure continues to be statistically insignificant, although the sign changes to negative. Road infrastructure, on the other hand, still exerts a positive impact on industrial development, but the parameter is only significant for RDQLPA. Furthermore, the magnitudes have decreased from some 0.3 to between 0.13 and 0.15 for any road and between 0.11 and 0.13 for paved roads. In other words, while it was road quality that mattered for the long term, for growth it is hard to tell whether it makes a (statistical) difference. Economically, increasing industrial growth from 3.6 to about 3.73 (RDQLPA) is still an achievement, albeit it has to be acknowledged that in three out four cases road infrastructure does not significantly increase manufacturing growth. Two other effects worth reporting is that ΔINST now enters with a coefficient of about 0.14, while that of ΔH is reduced to between 0.17 and 0.30 depending on regression. ΔMEXP remains statistically insignificant with a parameter essentially at zero.

While growth of railway infrastructure continues to be an insignificant determinant of manufacturing growth, FE-IV (Table 14) actually recovers all variables representing road infrastructure. However, it is only in the case of RDQLPA that road is tested to be statistically endogenous. Assuming that ROADPC and ROADPA are, indeed, endogenous, the total impact of a percentage increase in either of these variables increases manufacturing growth by about 0.3 percentage points. Interestingly, the total impact when accounting for quality reduces to 0.2 percentage points. The conclusion to draw is that growth of railway infrastructure is not statistically correlated with the pace of industrialization, while, somewhat guardedly, one may conclude that faster growth of road infrastructure will lead to faster industrial development.

6.2.2. Meta-countries

Does infrastructure result in differential growth rates across stages of development? This is the question addressed in Table 15, which presents the results for meta-countries. As there are very few incidences of endogeneity, the focus here will be on the FE estimator.

It is only in the fast-growing Tiger economies that railway infrastructure produces large growth effects.[22] The total growth impact of a percentage point increase in railways is about 0.7 percentage points for ΔRAILPC and ΔRAILPA. This seems excessively large and does not have a counterpart anywhere else in the sample. Large negative effects are registered for

[22] Only Lower-mid incomers and the Tigers display statistically significant parameters for RAILPC. For RAILPA, parameters are only significant at the Lower-mid income level.

the two lowest income groups, suggesting that the pace of investment in railway infrastructure may actually result in overprovision of such services. For Upper-mid incomers the impact is zero, while it is also negative at the highest income level. The general conclusion, then, is that increasing the investment rate in railway infrastructure is unlikely to increase industrial growth, except in the case of the Tigers.

Turning to road infrastructure, positive total impacts are recorded for ΔROADPC and ΔROADPA across all country groups.[23] The largest impacts occur at the two highest income levels and decline with income, and the impact is also very small for the Tigers. This runs counter to expectations and any role that road infrastructure might have for furthering convergence. The paved counterparts, however, have a different ordering of country groups. In this case, the largest growth impact is for Lower- and Upper-mid incomers, followed by Low and Tigers, with a negative impact at the highest income level. The latter income group is the only one with statistically significant estimates. Although this appears closer to expectations, the total impacts are fairly small and range from a slight negative to a maximum of 0.17 for Lower-mid. The only case where FE-IV is applied also occurs here and produces a total impact of nearly 0.2 for the Tiger economies. One may possibly conclude, like in the case of railway infrastructure, that the largest growth impact is to be had for the Asian tigers. Actually, these countries may be proof that transport infrastructure is an integral part of any development strategy.

7. Conclusions

This paper set out to answer two questions. The first concerned to what extent transport infrastructure has any explanatory power for why some countries have managed to industrialize while others have not. More broadly, that question could be interpreted to speak to the issue of transport infrastructure in long-term development. The second question was of a more short-term nature. It asked whether differential growth rates of transport infrastructure can explain differential rates of industrialization. To answer these questions, a simple empirical model, drawing from the deep determinants literature as well as the one on structural change, was formulated. Nearly 80 industrialized and developing countries were analyzed for a time period of 1970 to 2000.

Controlling for econometric issues, such as omitted variables, reverse causality and endogeneity bias, it was found that transport infrastructure, indeed, carries significant

[23] But are only significant in the case of Upper-mid and Tiger economies; the latter only for ROADPA.

explanatory power for why some countries have succeeded to industrialize while others have not. In particular, the impact of railway infrastructure was shown to be large. For the preferred regression, a 10 per cent increase of such infrastructure leads to an expansion of manufacturing per capita amounting to four per cent. This is a seriously large effect. However, it needs to be borne in mind that this is not the economy-wide impact. To compute the impact of railway infrastructure on GDP per capita *through* the industry channel, the four per cent needs to be mitigated by the fact that industry constitutes on average about 20 per cent of GDP, which leads to an impact of 0.8 per cent. This is not unreasonable seen from a long-term development perspective.

Based on IV-estimators, the extent to which road infrastructure impacts on manufacturing was shown to depend on how such infrastructure is scaled in that roads are only significant when scaled with land area. For non-IV estimators scaling is not very important. The impact of a 10 per cent increase of the total road network per land area, independent of it being paved or not, is 3.3 per cent. If paved, road infrastructure causes a five per cent growth of manufacturing. Taken together, there is little doubt that transport infrastructure importantly relates to industrialization.

A hypothesis was that transport infrastructure would impact differently across stages of development. Based on RAILPC, the largest effect, indeed, occurs at the lowest income levels, while in the case of RAILPA the indication is that for the lowest income group such infrastructure may actually be overprovided. For road infrastructure, especially paved roads, the largest effects are recorded for the fast-growing Asian tigers and the lowest income groups.

Turning to the growth of manufacturing, growth of railway infrastructure was seen not to be statistically important when analyzing the sample as a whole. Growth of road infrastructure, on the other hand, does cause faster industrial development. Surprisingly, it seems more important to have faster growth of the total road network than of paved roads. In the case of meta-countries, faster rate of investment in railway infrastructure is likely to spur industrial development in the Tiger economies, while for the other country groups this does not seem to be the case. This appears to be the case for road infrastructure as well, implying that Tigers should increase their spending on roads. However, in this case also other country groups would benefit from investment in roads. Having said that, the general impression, nevertheless, is that the growth dividend of road infrastructure is quite small. In other words, there might be other areas where public expenditures are more critical.

Because investment in transport infrastructure is a major undertaking for any country and because the benefit of such infrastructure is increasing in the number of users, there is a fundamental role to be played by international organizations in developing countries. Transport networks should not be confined to individual countries, but had better connect several countries in a region for the enjoyment of full benefits. Here, of course, lies a coordination problem because one cannot expect a country to build a road for another country, or put differently, benefits of cross-border roads accrue to more than one country and if funded by only one party they simply will not be constructed. International organizations or other third-party constellations such as bilateral aid agencies can bridge such gaps. For example, the United Kingdom is contributing to rebuild roads and rail systems in the Democratic Republic of Congo. An example of what can be achieved is the reconstructed railway network from Durban, across Zimbabwe and Zambia at Victoria Falls and up to Ndola at the Zambian and the Democratic Republic of Congo border. What used to take more than a month for the freight train from Ndola to Durban now only takes about three days (www.guardian.co.uk, 2009).

An often under-appreciated feature of infrastructure is the role of maintenance, on which Hulten (1996) has researched and shown to be significantly important.[24] Easterly (2009) relates this neglect of maintenance to the incentive to build new visible road rather than provide invisible services such as that of the former. The measures used in this paper do not account for the condition of rail or roads—except for the paved road dimension—and the prevalence of potholes and other kinds of dysfunctions could in many cases imply that in reality that transport possibilities are non-existent. Data wise the correct "value" of, say, a road might therefore be zero rather than some positive number. The implication for the present study is an overestimation of the *functional* stock of transport infrastructure, especially for low-income countries. In other words, the infrastructural gap could be even greater than shown here. It is possible that under such conditions, investing in rail and road networks could have even more profound positive effects on industrial development. That issue should be taken up by future research.

Transport infrastructure is integral to industrial development. Stating that means going beyond the impact suggested by the econometric work done for this paper. For example, the return to investment in schools and hospitals is likely to be greater when there is a good transport network available, since transport infrastructure increases access to such services.

[24] The World Development Report 1994 (World Bank, 1994) goes beyond the quantity of railways and roads and also discusses the quality of infrastructure services as well as the role of maintenance.

Likewise, private sector investments have a greater probability of being successful if the government provides roads and railways or other kinds of infrastructure. A good example is provided by Hausmann (2008) who gives the example of a hotel that will be built only if an airport is constructed nearby so that tourists can transport themselves to the hotel. In Murphy, Schleifer and Vishny (1989) style, this can be turned around so that the airport will not be constructed unless the government is sure of the establishment of the hotel. This sort of coordination problem is prevalent in developing countries and slows down development. Hence, transport infrastructure could very well be one of the key bottlenecks to industrialization and overall development (Jones, 2008).

Whether investment in transport infrastructure can drive growth by creating demand over and above its own investment is a different issue. In other words, is transport infrastructure a necessary condition in the sense of triggering growth or is it that only in the case when countries are poised for growth, but are facing infrastructural bottlenecks should governments react by relieving the economy of such bottlenecks? This is not a question that is easy to answer, but it seems easier to conceive of the latter. Yet, the regression results suggest that it is transport infrastructure that drives manufacturing growth and not the other way around.

When there is strong demand, but there are supply constraints public investment in transport infrastructure can do wonders and, thereby, cause growth by relief of such constraints. If there is little demand, it probably will not help much to build another road or railroad and growth will not be driven by public investment. Incidentally, public investment would occur in a low demand situation and in terms of causality could actually mimic and be the reciprocal of high demand and low public investment, thus statistically reinforcing the direction of causation going from infrastructure to growth. The policy decision of governments, thus, needs to inform itself of the demand situation before deciding on investing in infrastructures, especially in developing countries where resources are relatively scarce and trade offs are plentiful.

What may be missing in the analysis here is a full account of the role of dynamics. For example, past manufacturing production may be an important predictor of current output, the impact of infrastructure might only be felt after some time or output may increase in anticipation of investments in infrastructure. To some extent, dynamics is captured in the instruments vector, where up to three lags are allowed, but it must be acknowledged that not serious modelling attempt has been made. The levels estimations seek to capture long-run behaviour and as such dynamics appear less important. Short-term behaviour, however, is more uncertain and it is likely that growth of infrastructure does not contemporaneously affect industrial development.

Data quality across countries is likely to differ significantly, which means that the stages of development analysis may be biased.[25] Furthermore, although the income groups have been ranked according to their point estimates and rates of return, no formal statistical tests have been carried out that differences are actually statistically different. For both reasons, one needs to view the results with some humility and see them as indicative rather than sheer facts.

Finally, one of the reasons for investigating the impact of transport infrastructure at different stages of development was the possibility of non-linearities and threshold effects. However, a different approach to the one adopted here, that is to form meta-countries based on income levels, would be to allow the data to do the job. The approaches suggested by Hansen (1999) and Caner and Hansen (2004) are two possible ways to deal with this.

These caveats need to be acknowledged and be addressed in future research. Doing so will inevitably provide further evidence regarding the importance of transport infrastructure for industrial development. Until then, this paper hopefully has contributed new insights useful for researchers and policy makers alike.

[25] That issues of data quality and accurate coverage not only apply to developing countries, although problems ought to be more severe in those countries, is exemplified by the proposal for a new architecture for the US national accounts (Jorgenson and Landefeld, 2009).

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Table 1 List of countries

HIGH INCOME	UPPER-MID	LOW-MID	LOW INCOME	TIGERS
	Income per capita = 6,001 and above in year 2000, excluding OECD + Israel	*Income per capita = 3,001-6,000 in year 2000*	*Income per capita = up to 3,000 in year 2000*	
Australia	Argentina	Algeria	Bangladesh	China
Austria	Barbados *	Colombia	Benin	India
Belgium	Botswana	Costa Rica	Bolivia	Indonesia
Canada	Chile	Dominican Republic	Cameroon	Korea, Republic of
Denmark	Mauritius	Ecuador	Central African Rep. *	Malaysia
Finland	Mexico	Egypt	Congo	Singapore
France	Panama	El Salvador	Ghana	Thailand
Greece	South Africa	Fiji	Guinea Bissau	
Italy	Syria	Guatemala	Honduras	
Japan	Trinidad and Tobago	Iran	Kenya	
New Zealand	Tunisia	Jamaica	Malawi	
Norway	Turkey	Jordan	Mali	
Portugal	Uruguay	Pakistan	Nepal	
Spain	Venezuela	Paraguay	Nicaragua	
Sweden		Peru	Niger	
Switzerland		Philippines	Papua New Guinea	
UK		Sri Lanka	Rwanda	
USA			Senegal	
			Tanzania, U. Rep. of	
			Togo	
			Uganda	
			Zambia	
			Zimbabwe	

Note: There are 77 countries in the RAIL dataset and 79 countries in the ROAD dataset.

* Not included in the railway dataset.

Table 2 Descriptive statistics (in logs)

Variable	Mean	Stand. Dev.	Min	Max
*Levels of**				
MVA per capita	5.823	1.759	2.237	8.736
RAILPC	-1.505	1.451	-6.011	3.239
RAILPA	-4.467	1.660	-8.195	-0.077
ROADPC	1.421	1.083	-2.268	3.956
ROADPA	-1.585	1.360	-4.425	1.424
RDQLPC	0.273	1.447	-2.777	2.820
RDQLPA	-2.733	1.936	-6.456	1.355
AGR	7.625	1.530	5.131	9.992
MEXP	3.194	1.159	0.488	4.554
INST	1.759	0.160	1.342	2.079
H	1.613	0.540	-0.338	2.439
*Growth of***				
MVA per capita	0.024	0.028	-0.152	0.101
RAILPC	-0.016	0.009	-0.073	-0.002
RAILPA	0.000	0.007	-0.048	0.019
ROADPC	-0.000	0.014	-0.065	0.040
ROADPA	0.016	0.015	-0.031	0.057
RDQLPC	0.010	0.020	-0.116	0.075
RDQLPA	0.027	0.020	-0.083	0.087
AGR	0.026	0.017	-0.028	0.068
MEXP	0.026	0.049	-0.245	0.272
INST	0.007	0.009	-0.022	0.067
H	0.016	0.010	0.001	0.054

* In 2000.

** Average, 1970-2000.

Table 3 Comparison of infrastructure stocks across meta-countries, relative to high-income, per cent, year = 2000

	MVAPC	RAILPC	RAILPA	ROADPC	ROADPA	RDQLPC	RDQLPA
High	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Low	1.32	18.10	14.68	16.24	10.49	3.36	2.17
Lower-mid	7.62	14.81	12.43	21.25	19.75	7.14	6.63
Upper-mid	14.84	54.44	40.74	38.37	26.93	18.20	12.80
Tigers	9.55	12.28	52.52	11.37	48.63	7.24	30.94

Table 4 Transport infrastructure and Manufacturing per capita, OLS

	OLS	OLS	OLS	OLS	OLS	OLS
Constant	-1.894***	-1.910***	2.105***	1.704***	-2.001***	-1.949***
	(12.61)	(9.85)	(14.87)	(10.17)	(11.80)	(9.95)
AGR	0.794***	0.780***	0.787***	0.777***	0.784***	0.770***
	(47.14)	(46.18)	(45.72)	(45.79)	(43.49)	(45.19)
MEXP	0.133***	0.133***	0.124***	0.104***	0.114***	0.120***
	(11.16)	(10.32)	(16.96)	(7.78)	(9.78)	(8.83)
INST	0.341***	0.291**	0.370***	0.316***	0.381***	0.381
	(2.92)	(2.49)	(3.20)	(2.69)	(3.28)	(3.23)
H	0.707***	0.741***	0.690***	0.721***	0.737***	0.763***
	(19.22)	(19.89)	(11.90)	(18.69)	(18.58)	(19.76)
RAILPC	0.047*					
	(1.81)					
RAILPA		-0.021				
		(0.99)				
ROADPC			0.125***			
			(4.55)			
ROADPA				0.025		
				(1.23)		
RDQLPC					0.073***	
					(3.09)	
RDQLPA						-0.015
						(0.84)
T	-0.025***	-0.012***	-0.013***	-0.019***	-0.019***	-0.019***
	(12.47)	(3.04)	(4.79)	(9.71)	(10.53)	(7.78)
TINT	-0.002**	0.002**	0.006***	0.001	-0.004*	0.001
	(2.17)	(2.52)	(4.41)	(1.57)	(3.98)	(1.64)
N	1618	1618	1665	1665	1662	1662
R^2	0.92	0.92	0.92	0.91	0.91	0.91
F [a]	3371.88***	3518.99***	3020.99***	3233.00***	2921.13***	2977.54***
	(7,1610)	(7,1610)	(7,1657)	(7,1657)	(7,1654)	(7,1654)

Note: All variables are in logs and absolute t-values in parentheses. ***, ** and * denote statistical significance at the 1, 5 and 10 per cent, respectively, small-sample correction carried out for FE, robust standard errors, N = number of observations and OLS = Ordinary Least Squares.

RAILPC = railways per capita, RAILPA = railways per land area, ROADPC = road per capita, ROADPA = road per land area, RDQLPC = paved road per capita, RDQLPA = paved road per land area, AGR = agricultural value added per worker, MEXP = manufacturing exports in manufacturing value added, INST = economic freedom, H = educational attainment level for population aged 15+, T = linear time trend and TINT = interaction term between trend and TRANSPORT INFRASTRUCTURE.

[a] For OLS: F-test for joint significance of parameters, F[k, N-k-1].

Table 5 Transport infrastructure and Manufacturing per capita, Random-effects

	RE	RE	RE	RE	RE	RE
Constant	-0.925*** (4.37)	0.654*** (2.62)	-0.686*** (2.91)	1.333*** (5.29)	0.879*** (3.29)	2.873*** (9.46
AGR	0.742*** (28.22)	0.601*** (22.43)	0.650*** (20.84)	0.499*** (17.01)	0.540*** (16.26)	0.386*** (12.39)
MEXP	0.083*** (4.42)	0.152*** (7.04)	0.065*** (4.01)	0.082*** (4.65)	0.062*** (3.90)	0.084*** (4.63)
INST	0.143** (2.02)	-0.009 (0.14)	0.047 (0.78)	0.052 (0.86)	0.019 (0.32)	0.082 (1.35)
H	0.668*** (12.73)	0.950*** (17.08)	0.381*** (6.56)	0.673*** (10.62)	0.309*** (4.84)	0.580*** (9.87)
RAILPC	0.202*** (6.66)					
RAILPA		-0.039 (1.55)				
ROADPC			0.483*** (13.86)			
ROADPA				0.329*** (10.58)		
RDQLPC					0.622*** (16.82)	
RDQLPA						0.394*** (12.09)
T	-0.022*** (16.69)	0.001 (0.52)	0.004** (2.04)	-0.010*** (7.45)	-0.006*** (3.79)	-0.009*** (6.18)
TINT	-0.006*** (8.45)	0.004*** (7.18)	-0.008*** (9.11)	0.005*** (8.15)	-0.005*** (8.30)	0.003*** (8.35)
N	1618	1618	1665	1665	1662	1662
R^2	0.92	0.92	0.89	0.85	0.86	0.76
F [a]	1775.10*** (7)	1680.30*** (7)	1545.04*** (7)	1633.17*** (7)	1937.49*** (7)	1770.90*** (7)

Note: All variables are in logs and absolute t-values in parentheses. ***, ** and * denote statistical significance at the 1, 5 and 10 per cent, respectively, small-sample correction carried out for FE, robust standard errors, N = number of observations and RE = Random-effects estimator.

RAILPC = railways per capita, RAILPA = railways per land area, ROADPC = road per capita, ROADPA = road per land area, RDQLPC = paved road per capita, RDQLPA = paved road per land area, AGR = agricultural value added per worker, MEXP = manufacturing exports in manufacturing value added, INST = economic freedom, H = educational attainment level for population aged 15+, T = linear time trend and TINT = interaction term between trend and TRANSPORT INFRASTRUCTURE.

[a] For RE: Wald-test for joint significance of parameters, F[k].

Table 6 Transport infrastructure and Manufacturing per capita, Fixed-effects

	FE	FE	FE	FE	FE	FE
Constant	0.071 (0.18)	0.747*** (1.86)	0.918** (2.41)	2.733*** (7.24)	1.446*** (4.07)	4.476*** (12.21)
AGR	0.648*** (14.05)	0.401*** (8.77)	0.500*** (11.14)	0.376*** (8.80)	0.490*** (11.57)	0.282*** (6.79)
MEXP	0.068*** (3.33)	0.140*** (6.18)	0.040** (2.41)	0.070*** (4.01)	0.057*** (3.46)	0.079*** (4.70)
INST	0.107 (1.53)	-0.087 (1.41)	-0.014 (0.24)	0.017 (0.29)	0.005 (0.08)	0.093 (1.62)
H	0.591*** (8.79)	0.883*** (13.29)	0.201*** (2.73)	0.548*** (6.89)	0.245*** (3.40)	0.409*** (6.13)
RAILPC	0.209*** (5.41)					
RAILPA		-0.135*** (4.56)				
ROADPC			0.529*** (14.33)			
ROADPA				0.401*** (10.71)		
RDQLPC					0.680*** (16.16)	
RDQLPA						0.581*** (12.55)
T	-0.017*** (8.21)	0.014*** (4.52)	0.013*** (4.98)	-0.004** (2.27)	-0.004** (2.00)	-0.007 (1.08)
TINT	-0.006*** (8.11)	0.005*** (9.60)	-0.008*** (9.19)	0.006*** (9.55)	-0.005*** (7.78)	0.004*** (10.48)
N	1618	1618	1665	1665	1662	1662
R^2	0.48	0.47	0.57	0.55	0.59	0.76
F [a]	100.47*** (7,1534)	114.46*** (7,1534)	117.42*** (7,1579)	122.54*** (7,1579)	146.23*** (7,1576)	164.47*** (7,1576)

Note: All variables are in logs and absolute t-values in parentheses. ***, ** and * denote statistical significance at the 1, 5 and 10 per cent, respectively, small-sample correction carried out for FE, robust standard errors, N = number of observations and FE = Fixed-effects estimator.

RAILPC = railways per capita, RAILPA = railways per land area, ROADPC = road per capita, ROADPA = road per land area, RDQLPC = paved road per capita, RDQLPA = paved road per land area, AGR = agricultural value added per worker, MEXP = manufacturing exports in manufacturing value added, INST = economic freedom, H = educational attainment level for population aged 15+, T = linear time trend and TINT = interaction term between trend and TRANSPORT INFRASTRUCTURE.

[a] For FE: F-test for joint significance of parameters, F[k+i, N-(k+i)].

Table 7 Transport infrastructure and Manufacturing per capita, RE-IV

	RE-IV	RE-IV	RE-IV	RE-IV	RE-IV	RE-IV
Constant	2.014 (1.43)	-0.854 (1.05)	-0.808*** (3.11)	1.836*** (3.09)	0.786 (1.18)	3.737*** (4.68)
AGR	0.569*** (11.96)	0.766*** (51.16)	0.688*** (15.30)	0.427*** (14.64)	0.549*** (8.72)	0.290*** (8.37)
MEXP	0.056*** (3.58)	0.090** (2.37)	0.088*** (4.93)	0.078*** (2.97)	0.052*** (2.90)	0.082*** (4.61)
INST	0.139* (1.90)	0.411*** (4.47)	0.098 (1.55)	0.097 (1.61)	0.020 (0.35)	0.078 (1.368)
H	0.374*** (4.16)	0.706*** (16.96)	0.525*** (3.38)	0.591*** (3.40)	0.358** (2.18)	0.519*** (3.61)
RAILPC	1.248*** (3.73)					
RAILPA		0.192 (1.20)				
ROADPC			0.145 (0.64)			
ROADPA				0.303* (1.70)		
RDQLPC					0.482** (2.16)	
RDQLPA						0.416*** (2.68)
T	-0.009** (2.43)	-0.050* (1.87)	-0.002 (0.32)	-0.006*** (3.11)	-0.006* (1.82)	-0.005 (1.55)
TINT	-0.014*** (5.57)	-0.006 (0.98)	-0.006*** (4.53)	0.005*** (3.91)	-0.005*** (3.66)	0.004*** (7.37)
N	1593	1491	1424	1472	1569	1637
R^2	0.68	0.92	0.92	0.84	0.88	0.71
Endogenous	Railpc	Railpa	Roadpc	Roadpa	Rdqlpc	Rdqlpa
Instruments	ΔPop_{t-1}	$Urbpop^2_{t-1}$ $\Delta Urbpop^2_{t-3}$	$\Delta Roadpa_{t-2}$ $\Delta Roadpa_{t-3}$ ΔPOP_{t-1}	Pop_{t-1} Pop_{t-3}	ΔPop_{t-1} ΔPop_{t-2}	ΔPop_{t-1}
F [a]	133.58*** (7,1509)	2477.85*** (7,1484)	269.27*** (7,1417)	257.07*** (7,1465)	262.17*** (7,1562)	260.51*** (7,1630)
First t-test [b]	0.072	0.055	0.965***	0.487***	0.468***	0.888***
Final t-test [c]	-0.055	-0.266*	-0.345	0.192	-0.106	0.068

Note: All variables are in logs and absolute t-values in parentheses. ***, ** and * denote statistical significance at the 1, 5 and 10 per cent, respectively, robust standard errors. N = number of observations, Endogenous = endogenous explanatory variable, Δ = first difference operator and RE-IV= Random-effects Instrumental Variables estimator.

RAILPC = railways per capita, RAILPA = railways per land area, ROADPC = road per capita, ROADPA = road per land area, RDQLPC = paved road per capita, RDQLPA = paved road per land area, AGR = agricultural value added per worker, MEXP = manufacturing exports in manufacturing value added, INST = economic freedom, H = educational attainment level for population aged 15+, POP = population, $URBPOP^2$ = share of urbanized population, T = linear time trend and TINT = interaction term between trend and TRANSPORT INFRASTRUCTURE.

[a] For RE-IV: Wald-test for joint significance of parameters, F[k, N-k]. [b] T-test for whether TRANSPORT INFRASTRUCTURE is endogenous in the first test round [c] T-test for whether TRANSPORT INFRASTRUCTURE is endogenous in the last test round [d] First stage t-values for instruments [e] χ^2-test for validity of instruments, χ^2 (instr.-1).

Table 8 Transport infrastructure and Manufacturing per capita, FE-IV

	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV
Constant	2.265***	2.591***	1.363***	3.283***	1.438**	4.022***
	(3.02)	(3.28)	(3.72)	(8.31)	(2.56)	(6.70)
AGR	0.567***	0.481***	0.489***	0.253***	0.486***	0.260***
	(11.58)	(7.85)	(9.49)	(6.89)	(9.10)	(7.15)
MEXP	0.056***	0.112***	0.059***	0.076***	0.049***	0.084***
	(3.48)	(6.99)	(3.38)	(4.62)	(2.87)	(5.45)
INST	0.139*	-0.004	0.018	0.038	-0.006	0.070
	(1.85)	(0.05)	(0.29)	(0.63)	(0.10)	(1.21)
H	0.371***	0.695***	0.281**	0.545***	0.365**	0.513***
	(4.01)	(7.97)	(1.99)	(4.90)	(2.05)	(4.28)
RAILPC	1.265***					
	(3.67)					
RAILPA		0.373***				
		(2.67)				
ROADPC			0.130			
			(0.65)			
ROADPA				0.221**		
				(2.05)		
RDQLPC					0.359	
					(1.28)	
RDQLPA						0.408***
						(3.07)
T	-0.008**	0.002	0.011**	0.003	-0.003	-0.003
	(2.31)	(0.40)	(2.31)	(1.26)	(1.23)	(0.99)
TINT	-0.014***	0.002*	-0.007***	0.007***	-0.004***	0.005***
	(5.45)	(1.87)	(6.85)	(7.92)	(2.63)	(8.54)
N	1593	1593	1424	1472	1569	1637
Endogenous	Railpc	Railpa	Roadpc	Roadpa	Rdqlpc	Rdqlpa
Instruments	ΔPop_{t-1}	ΔPop_{t-1}	$\Delta Roadpa_{t-2}$ $\Delta Roadpa_{t-3}$ ΔPop_{t-1}	$\Delta Roadpa_{t-3}$ ΔPop_{t-3}	ΔPop_{t-1} ΔPop_{t-2}	ΔPop_{t-1}
R^2	0.21	0.40	0.47	0.50	0.50	0.56
F [a]	125.75***	159.30***	154.24***	181.33***	164.71***	236.42***
	(84,1509)	(84,1509)	(86,1486)	(86,1386)	(86,1483)	(86,1551)
F [b]	57.37***	74.22***	104.92***	113.25***	113.66***	117.11***
	(76,1509)	(76,1509)	(78,1338)	(78,1386)	(78,1483)	(78,1551)
First t-test [c]	0.014	-0.312***	-0.806***	0.432***	0.487	0.486*
Final t-test [d]	0.883	0.559**	1.079***	-0.224*	-0.305	-0.170
Sargan [f] χ^2 (instr.-1)			0.936	1.492	0.051	

Note: All variables are in logs and absolute t-values in parentheses. ***, ** and * denote statistical significance at the 1, 5 and 10 per cent, respectively, small-sample correction carried out for FE-IV, robust standard errors. N = number of observations, Endogenous = endogenous explanatory variable, Δ = first difference operator, FE-IV = Fixed-effects Instrumental Variables estimator.

RAILPC = railways per capita, RAILPA = railways per land area, ROADPC = road per capita, ROADPA = road per land area, RDQLPC = paved road per capita, RDQLPA = paved road per land area, AGR = agricultural value added per worker, MEXP = manufacturing exports in manufacturing value added, INST = economic freedom, H = educational attainment level for population aged 15+, POP = population, T = linear time trend and TINT = interaction term between trend and TRANSPORT INFRASTRUCTURE.

[a] For FE-IV: F-test for joint significance of parameters, F[k+i, N-(k+i)]. [b] For FE-IV: F-test for whether the fixed effects are statistically significant F[i-1, N-(k+i]. [c] T-test for whether TRANSPORT INFRASTRUCTURE. is endogenous in the first test round [d] T-test for whether TRANSPORT INFRASTRUCTURE. is endogenous in the last test round [e] First stage t-values for instruments [f] χ^2-test for validity of instruments, χ^2 (instr.-1).

Table 9 Transport Infrastructure and Industrial Development, OLS, Random (RE) and Fixed-effects (FE) and RE and FE instrumental variables, Meta countries

		OECD	Upper-Mid	Lower-Mid	Low	Tigers
OLS	RAILPC	-0.069*** (2.80)	0.081 (0.95)	-0.029 (0.55)	0.458*** (6.81)	0.211 (1.33)
	TINT	-0.002 (1.47)	-0.007* (1.94)	0.000 (0.08)	-0.014*** (5.59)	-0.011* (1.86)
RE	RAILPC	-0.042 (0.83)	0.056 (1.39)	0.033 (0.80)	0.270*** (4.95)	0.211 (1.33)
	TINT	-0.003*** (3.68)	-0.004*** (3.18)	-0.000 (0.44)	-0.008*** (5.39)	-0.011* (1.86)
FE	RAILPC	-0.068 (1.30)	0.020 (0.55)	0.044 (0.96)	0.034 (0.22)	1.448*** (5.37)
	TINT	-0.003*** (4.01)	-0.004*** (3.47)	-0.001 (0.54)	-0.008*** (5.50)	-0.021*** (6.36)
RE-IV	RAILPC			0.455 (1.55)	0.617* (1.86)	
	TINT			-0.009 (1.42)	-0.010*** (5.55)	
FE-IV	RAILPC	-0.062 (0.37)				
	TINT	-0.003*** (3.19)				

OLS	RAILPA	-0.006 (0.20)	-0.088 (1.35)	-0.304*** (3.73)	0.017 (0.21)	0.298*** (10.64)
	TINT	0.005*** (3.88)	-0.000 (0.15)	0.015*** (4.58)	0.003 (0.13)	-0.009*** (6.92)
RE	RAILPA	-0.192*** (4.00)	-0.043 (1.25)	-0.365*** (7.49)	-0.030 (0.35)	0.298*** (10.64)
	TINT	0.006*** (9.31)	0.001 (1.09)	0.012*** (9.12)	0.003 (1.28)	-0.009*** (6.92)
FE	RAILPA	-0.286*** (5.50)	-0.068* (1.87)	-0.381*** (8.15)	-0.388** (2.00)	-0.096 (0.24)
	TINT	0.006*** (9.10)	0.001 (0.98)	0.012*** (9.38)	0.003 (1.39)	-0.009*** (5.69)
RE-IV	RAILPA			0.216* (1.69)		0.371*** (7.93)
	TINT			0.005** (2.46)		-0.011*** (5.73)
FE-IV	RAILPA			0.271* (1.70)		1.145 (1.22)
	TINT			0.005** (2.23)		-0.013*** (5.85)

OLS	ROADPC	0.017 (0.46)	0.551*** (3.23)	0.417*** (6.50)	0.195*** (3.18)	-0.247** (2.22)

	TINT	-0.001 (0.29)	-0.014** (2.25)	-0.008*** (2.67)	-0.005* (1.78)	-0.006 (1.01)
RE	ROADPC	0.064 (0.88)	0.475*** (4.25)	0.311*** (7.75)	0.345*** (5.23)	-0.247** (2.22)
	TINT	-0.002 (1.29)	-0.014*** (3.76)	-0.005** (2.23)	-0.008*** (6.01)	-0.006 (1.01)
FE	ROADPC	0.065 (0.79)	0.462*** (4.37)	0.299*** (7.12)	0.390*** (5.06)	0.083 (1.24)
	TINT	-0.002 (1.54)	-0.014*** (3.76)	-0.005** (2.12)	-0.007*** (3.80)	0.000 (0.07)
RE-IV	ROADPC		0.193 (0.67)	0.692*** (3.40)	0.582*** (5.16)	
	TINT		-0.010 (1.59)	-0.016*** (2.98)	-0.005*** (2.70)	
FE-IV	ROADPC			0.720*** (3.45)	0.683*** (4.81)	
	TINT			-0.016*** (3.04)	-0.003 (1.19)	
OLS	ROADPA	0.027 (1.16)	-0.522*** (4.62)	-0.035 (0.67)	0.091 (0.82)	0.281*** (6.48)
	TINT	0.004*** (3.48)	0.012** (2.55)	0.008*** (3.86)	-0.002 (0.47)	-0.011*** (4.49)
RE	ROADPA	-0.092* (1.89)	0.052 (0.75)	0.123*** (4.06)	0.491*** (5.89)	0.281*** (6.48)
	TINT	0.004*** (8.25)	0.007*** (3.79)	0.006*** (6.09)	-0.002 (0.72)	-0.011*** (4.49)
FE	ROADPA	-0.187*** (2.73)	0.167** (2.09)	0.133*** (4.56)	0.578*** (6.25)	-0.005 (0.12)
	TINT	0.004*** (8.24)	0.006*** (3.30)	0.006*** (6.12)	0.000 (0.09)	-0.012*** (5.04)
RE-IV	ROADPA		0.982 (1.06)		0.984*** (4.29)	0.572*** (7.56)
	TINT		-0.052 (1.33)		-0.012*** (2.28)	-0.023*** (7.01)
FE-IV	ROADPA	0.360* (1.68)	0.870*** (4.13)		0.852*** (4.63)	0.254*** (2.67)
	TINT	0.003*** (2.66)	-0.003 (1.14)		-0.004 (0.97)	-0.017*** (8.72)
OLS	RDQLPC	0.021 (0.55)	-0.647*** (3.44)	0.188** (2.08)	0.133 (1.41)	0.048 (0.51)
	TINT	0.000 (0.10)	-0.005 (0.54)	-0.010** (2.48)	-0.001 (0.29)	-0.019*** (4.05)
RE	RDQLPC	0.200*** (6.74)	0.275** (2.49)	0.389*** (8.54)	0.579*** (7.66)	0.048 (0.51)
	TINT	0.001 (0.46)	-0.009** (2.55)	-0.004** (2.00)	-0.016*** (7.70)	-0.019*** (4.05)
FE	RDQLPC	0.202*** (6.05)	0.329*** (3.16)	0.411*** (8.62)	0.605*** (6.97)	0.628*** (11.58)

	TINT	0.000 (0.25)	-0.008** (2.53)	-0.003* (1.76)	-0.017*** (7.02)	-0.008*** (3.83)
RE-IV	RDQLPC	0.572*** (2.68)			0.727*** (6.32)	
	TINT	0.001 (0.65)			-0.017*** (7.92)	
FE-IV	RDQLPC				0.689*** (5.43)	
	TINT				-0.016*** (7.27)	

OLS	RDQLPA	0.015 (0.87)	-0.508*** (11.58)	-0.080 (1.57)	-0.163*** (2.68)	0.255*** (6.44)
	TINT	0.003*** (3.45)	0.012*** (6.75)	0.005** (2.21)	0.008*** (2.74)	-0.012*** (5.75)
RE	RDQLPA	0.086*** (3.30)	-0.076 (1.21)	0.148*** (3.25)	0.231*** (2.61)	0.255*** (6.44)
	TINT	0.003*** (6.95)	0.005*** (3.57)	0.004*** (4.10)	0.003 (1.39)	-0.012*** (5.75)
FE	RDQLPA	0.123*** (4.00)	0.190* (1.73)	0.231*** (5.86)	0.605*** (4.83)	0.554*** (10.35)
	TINT	0.003*** (7.34)	0.004*** (3.42)	0.004*** (3.94)	0.004** (2.12)	-0.010*** (7.57)
RE-IV	RDQLPA	0.485*** (4.41)	0.982 (1.06)		0.733*** (3.11)	0.492*** (7.53)
	TINT	0.002*** (2.86)	-0.052 (1.33)		-0.001 (0.49)	-0.020*** (7.86)
FE-IV	RDQLPA			0.340* (1.80)	0.688*** (3.76)	0.810*** (9.27)
	TINT			0.003** (2.35)	0.004** (2.17)	-0.011*** (8.15)

Note: All variables are in logs and absolute t-values in parentheses. ***, ** and * denote statistical significance at the 1, 5 and 10 per cent, respectively, small-sample correction carried out for FE-IV.

RAILPC = railways per capita, RAILPA = railways per land area, ROADPC = road per capita, ROADPA = road per land area, RDQLPC = paved road per capita, RDQLPA = paved road per land area, TINT = interaction term between trend and TRANSPORT INFRASTRUCTURE.

Table 10 Transport infrastructure and Industrial Development, OLS

	OLS	OLS	OLS	OLS	OLS	OLS
Constant	0.024***	0.019***	0.016***	0.013***	0.012**	0.007
	(3.97)	(4.21)	(3.69)	(2.83)	(2.55)	(1.36)
ΔAGR	0.137***	0.141***	0.160***	0.159***	0.134***	0.138***
	(5.28)	(5.39)	(6.14)	(6.16)	(5.40)	(5.59)
ΔMEXP	0.004	0.004	0.009	0.009	0.005	0.006
	(0.36)	(0.36)	(0.93)	(0.85)	(0.52)	(0.59)
ΔINST	0.118	0.099	0.110	0.116	0.106	0.130*
	(1.48)	(1.24)	(1.42)	(1.49)	(1.39)	(1.68)
ΔH	0.439***	0.434***	0.447***	0.393***	0.410***	0.365***
	(4.52)	(4.57)	(4.87)	(4.34)	(4.78)	(4.24)
ΔRAILPC	0.280					
	(1.00)					
ΔRAILPA		0.366				
		(1.28)				
ΔROADPC			0.275***			
			(2.62)			
ΔROADPA				0.236**		
				(2.39)		
ΔRDQLPC					0.280***	
					(3.55)	
ΔRDQLPA						0.312***
						(4.01)
T	-0.001**	-0.000*	-0.000*	-0.000*	-0.000	-0.000
	(1.99)	(1.69)	(1.67)	(1.65)	(0.82)	(0.25)
TINT	-0.010	-0.019	0.001	0.002	-0.002	-0.005
	(0.81)	(1.44)	(0.14)	(0.32)	(0.42)	(1.30)
N	1389	1386	1463	1465	1490	1491
R^2	0.05	0.05	0.08	0.07	0.08	0.07
F [a]	7.78***	8.20***	14.04***	13.74***	15.32***	14.31***
	(7,1381)	(7,1378)	(7,1455)	(7,1457)	(7,1482)	(7,1483)

Note: All variables are in logs and absolute t-values in parentheses. ***, ** and * denote statistical significance at the 1, 5 and 10 per cent, respectively, N = number of observations, Δ = first difference operator and OLS = Ordinary Least Squares.

RAILPC = railways per capita, RAILPA = railways per land area, ROADPC = road per capita, ROADPA = road per land area, RDQLPC = paved road per capita, RDQLPA = paved road per land area, AGR = agricultural value added per worker, MEXP = manufacturing exports in manufacturing value added, INST = economic freedom, H = educational attainment level for population aged 15+.

[a] For OLS: F-test for joint significance of parameters, F[k, N-k-1].

Table 11 Transport infrastructure and Industrial Development, Random-effects

	RE	RE	RE	RE	RE	RE
Constant	0.023***	0.022***	0.017***	0.014**	0.018***	0.015**
	(3.13)	(3.66)	(2.95)	(2.30)	(2.92)	(2.25)
ΔAGR	0.122***	0.124***	0.144***	0.139***	0.119***	0.119***
	(4.96)	(5.00)	(5.72)	(5.55)	(4.99)	(5.02)
ΔMEXP	-0.005	-0.005	0.002	0.003	-0.002	-0.002
	(0.55)	(0.49)	(0.26)	(0.29)	(0.28)	(0.20)
ΔINST	0.147*	0.133*	0.140*	0.141*	0.138*	0.148*
	(1.86)	(1.68)	(1.80)	(1.82)	(1.80)	(1.93)
ΔH	0.225**	0.249**	0.335***	0.319***	0.272***	0.256***
	(2.25)	(2.49)	(3.37)	(3.25)	(2.88)	(2.70)
ΔRAILPC	0.006					
	(0.02)					
ΔRAILPA		-0.122				
		(0.42)				
ΔROADPC			0.163			
			(1.57)			
ΔROADPA				0.141		
				(1.53)		
ΔRDQLPC					0.137*	
					(1.83)	
ΔRDQLPA						0.165**
						(2.25)
T	-0.000	-0.000**	-0.000*	-0.000*	-0.000*	-0.000
	(1.63)	(2.21)	(1.93)	(1.729)	(1.83)	(1.25)
TINT	0.002	0.004	0.001	0.002	0.000	-0.003
	(0.13)	(0.29)	(0.11)	(0.40)	(0.02)	(0.68)
N	1389	1386	1463	1465	1490	1491
R^2	0.04	0.02	0.03	0.07	0.07	0.07
F [a]	40.41***	41.24***	62.88***	62.12***	59.87***	57.71***
	(7)	(7)	(7)	(7)	(7)	(7)

Note: All variables are in logs and absolute t-values in parentheses. ***, ** and * denote statistical significance at the 1, 5 and 10 per cent, respectively, N = number of observations, Δ = first difference operator and RE = Random-effects estimator.

RAILPC = railways per capita, RAILPA = railways per land area, ROADPC = road per capita, ROADPA = road per land area, RDQLPC = paved road per capita, RDQLPA = paved road per land area, AGR = agricultural value added per worker, MEXP = manufacturing exports in manufacturing value added, INST = economic freedom, H = educational attainment level for population aged 15+.

[a] For RE: Wald-test for joint significance of parameters, F[k].

Table 12 Transport infrastructure and Industrial Development, Fixed-effects

	FE	FE	FE	FE	FE	FE
Constant	0.025***	0.025***	0.020***	0.017***	0.021***	0.018***
	(3.80)	(5.30)	(4.27)	(3.46)	(4.33)	(3.49)
ΔAGR	0.116***	0.117***	0.137***	0.132***	0.112***	0.112***
	(4.67)	(4.68)	(5.37)	(5.16)	(4.64)	(4.65)
ΔMEXP	-0.008	-0.008	-0.001	-0.006	-0.006	-0.005
	(0.94)	(0.88)	(0.13)	(0.07)	(0.70)	(0.66)
ΔINST	0.141*	0.130	0.131*	0.132*	0.130*	0.136*
	(1.75)	(1.62)	(1.66)	(1.67)	(1.66)	(1.73)
ΔH	0.171*	0.196*	0.299***	0.294***	0.230***	0.220***
	(1.69)	(1.93)	(2.93)	(2.90)	(2.35)	(2.24)
ΔRAILPC	-0.086					
	(0.29)					
ΔRAILPA		-0.296				
		(0.95)				
ΔROADPC			0.150			
			(1.39)			
ΔROADPA				0.129		
				(1.36)		
ΔRDQLPC					0.109	
					(1.44)	
ΔRDQLPA						0.133*
						(1.80)
T	-0.000	-0.000**	-0.000*	-0.000	-0.000*	-0.000
	(1.38)	(2.21)	(1.80)	(1.53)	(1.84)	(1.35)
TINT	0.006	0.013	-0.001	0.001	0.000	-0.002
	(0.43)	(0.89)	(0.14)	(0.26)	(0.04)	(0.48)
N	1389	1386	1463	1465	1490	1491
R^2	0.03	0.03	0.05	0.05	0.04	0.04
F [a]	4.95***	5.07***	7.17***	7.15***	6.44***	6.39***
	(7,1309)	(7,1306)	(7,1381)	(7,1383)	(7,1408)	(7,1409)

Note: All variables are in logs and absolute t-values in parentheses. ***, ** and * denote statistical significance at the 1, 5 and 10 per cent, respectively, small-sample correction carried out for FE.
N = number of observations, Δ = first difference operator and FE = Fixed-effects estimator.

RAILPC = railways per capita, RAILPA = railways per land area, ROADPC = road per capita, ROADPA = road per land area, RDQLPC = paved road per capita, RDQLPA = paved road per land area, AGR = agricultural value added per worker, MEXP = manufacturing exports in manufacturing value added, INST = economic freedom, H = educational attainment level for population aged 15+.

[a] For FE: F-test for joint significance of parameters, F[k+i, N-(k+i)].

Table 13 Transport infrastructure and Industrial Development, RE-IV

	RE-IV	RE-IV	RE-IV	RE-IV	RE-IV	RE-IV
Constant	0.014 (0.21)	0.015 (1.22)	0.013 (1.45)	0.007 (0.56)	-0.009 (0.74)	0.001 (0.04)
ΔAGR	0.124*** (5.30)	0.124*** (5.65)	0.138*** (6.56)	0.141*** (6.60)	0.118*** (5.12)	0.126*** (5.64)
ΔMEXP	-0.009 (1.02)	-0.009 (1.13)	0.002 (0.23)	-0.002 (0.23)	-0.005 (0.57)	-0.002 (0.30)
ΔINST	0.259* (1.65)	0.167** (2.12)	0.167** (2.44)	0.184*** (2.68)	0.208*** (2.86)	0.198*** (2.72)
ΔH	0.316 (1.45)	0.230** (2.24)	0.283*** (2.87)	0.314*** (2.82)	0.286*** (2.94)	0.285*** (2.71)
ΔRAILPC	0.383 (0.09)					
ΔRAILPA		1.229 (0.40)				
ΔROADPC			0.953* (1.87)			
ΔROADPA				0.225 (0.42)		
ΔRDQLPC					1.408** (2.33)	
ΔRDQLPA						0.440 (0.66)
T	-0.000 (0.05)	-0.000 (0.89)	-0.000 (1.34)	-0.000 (0.20)	0.001 (1.50)	0.000 (1.85)
TINT	-0.015 (0.08)	-0.053 (0.40)	-0.039 (1.59)	-0.003 (0.12)	-0.061** (2.09)	-0.015 (0.48)
N	1301	1331	1438	1407	1435	1436
R^2	0.04	0.04	0.06	0.07	0.04	0.07
Endogenous	Railpc	Railpa	Roadpc	Roadpa	Rdqlpc	Rdqlpa
Instruments	ΔPop_{t-3}	$Railpa_{t-1}$ $Urbpop^2_{t-1}$ $Urbpop^2_{t-3}$	$Roadpc_{t-2}$	$Roadpa_{t-3}$	$Rdqlpc_{t-2}$ $Rdqlpc_{t-3}$	$Rdqlpa_{t-2}$ $Rdqlpa_{t-3}$
F [a]	8.14*** (7,1294)	6.76*** (7, 1324)	10.64*** (7,1431)	10.60*** (7,1400)	9.13*** (7,1428)	9.26*** (7,1429)
First t-test [b]	5.536**	1.002	-0.170	-1.209*	0.997	0.697
Final t-test [c]	0.020	6.789*	1.898***	0.643	1.586**	0.965

Note: All variables are in logs and absolute t-values in parentheses. ***, ** and * denote statistical significance at the 1, 5 and 10 per cent, respectively, robust standard errors, Endogenous = endogenous explanatory variable, Δ = first difference operator, N = number of observations and RE-IV = Random-effects Instrumental Variables estimator.

RAILPC = railways per capita, RAILPA = railways per land area, ROADPC = road per capita, ROADPA = road per land area, RDQLPC = paved road per capita, RDQLPA = paved road per land area, AGR = agricultural value added per worker, MEXP = manufacturing exports in manufacturing value added, INST = economic freedom, H = educational attainment level for population aged 15+, POP = population, T = linear time trend and TINT = interaction term between trend and TRANSPORT INFRASTRUCTURE.

[a] For RE-IV: Wald-test for joint significance of parameters, F[k, N-k]. [b] Test for whether TRANSPORT INFRASTRUCTURE is endogenous in the first test round [c] Test for whether TRANSPORT INFRASTRUCTURE is endogenous in the last test round. [d] First stage t-values for instruments [e] χ^2-test for validity of instruments, χ^2 (instr.-1).

Table 14 Transport infrastructure and Industrial Development, FE-IV

	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV
Constant	0.019	0.024***	0.014***	0.004	0.010*	0.001
	(0.72)	(5.07)	(2.74)	(0.54)	(1.69)	(0.09)
ΔAGR	0.116***	0.119***	0.141***	0.136***	0.115***	0.114***
	(5.31)	(5.38)	(6.52)	(6.25)	(5.31)	(5.25)
ΔMEXP	-0.008	-0.008	-0.002	-0.002	-0.008	-0.007
	(0.98)	(0.95)	(0.26)	(0.26)	(0.96)	(0.88)
ΔINST	0.149**	0.142*	0.177**	0.184***	0.185***	0.198***
	(2.16)	(1.83)	(2.49)	(2.61)	(2.67)	(2.85)
ΔH	0.156	0.189*	0.310***	0.264**	0.251***	0.213**
	(1.51)	(1.85)	(3.00)	(2.48)	(2.62)	(2.19)
ΔRAILPC	-0.435					
	(0.65)					
ΔRAILPA		0.744				
		(0.37)				
ΔROADPC			0.777*			
			(1.76)			
ΔROADPA				0.679**		
				(2.06)		
ΔRDQLPC					0.481**	
					(2.40)	
ΔRDQLPA						0.545***
						(2.89)
T	-0.000	-0.000*	-0.000	0.000	0.000	0.000
	(0.31)	(1.85)	(0.56)	(0.84)	(0.26)	(1.33)
TINT	0.021	-0.031	-0.031	-0.026	-0.018*	-0.022**
	(0.72)	(0.36)	(1.46)	(1.58)	(1.79)	(2.34)
N	1389	1362	1405	1407	1435	1436
Endogenous.	Railpc	Railpa	Roadpc	Roadpa	Roadpa	Rdqlpa
Instruments	Pop_{t-1}	Pop_{t-2}	$Roadpc_{t-3}$	$Roadpa_{t-3}$	$Rdqlpc_{t-1}$ $Rdqlpc_{t-2}$ $Rdqlpc_{t-3}$	$Rdqlpc_{t-1}$ $Rdqlpa_{t-3}$
R^2	0.03	0.02	0.04	0.04	0.03	0.03
F [a]	6.10***	5.95***	10.18***	10.17***	8.32***	8.39***
	(80,1309)	(80,1282)	(82,1323)	(82,1325)	(82,1353)	(82,1354)
F [b]	5.17***	4.71***	4.46***	4.62***	4.27***	4.36***
	(74,1309)	(72,1282)	(74,1323)	(74,1325)	(74,1353)	(74,1354)
First t-test [c]	-1.156	1.480	-0.048	0.209	0.166	0.395
Final t-test [d]	-0.438	0.858	0.546	0.358	0.439	0.487*
Sargan [e] χ^2 (instr.-1)					2.855	3.280

Note: All variables are in logs and absolute t-values in parentheses. ***, ** and * denote statistical significance at the 1, 5 and 10 per cent, respectively, small-sample correction carried out for FE, robust standard errors, Endogenous = endogenous explanatory variable, Δ = first difference operator, N = number of observations and FE-IV = Fixed-effects Instrumental Variables estimator.

RAILPC = railways per capita, RAILPA = railways per land area, ROADPC = road per capita, ROADPA = road per land area, RDQLPC = paved road per capita, RDQLPA = paved road per land area, AGR = agricultural value added per worker, MEXP = manufacturing exports in manufacturing value added, INST = economic freedom, H = educational attainment level for population aged 15+, POP = population, T = linear time trend and TINT = interaction term between trend and TRANSPORT INFRASTRUCTURE.

[a] For FE-IV: F-test for joint significance of parameters, F[k+i, N-(k+i)]. [b] For FE-IV: F-test for whether the fixed effects are statistically significant F[i-1, N-(k+i]. [c] T-test for whether TRANSPORT INFRASTRUCTURE is endogenous in the first test round [d] T-test for whether TRANSPORT INFRASTRUCTURE is endogenous in the last test round [e] First stage t-values for instruments [f] χ^2-test for validity of instruments, χ^2 (instr.-1).

Table 15 Transport Infrastructure and Industrial Development, OLS, Random (RE) and Fixed-effects (FE) and RE and FE instrumental variables, Meta countries

		OECD	Upper-Mid	Lower-Mid	Low	Tigers
OLS	ΔRAILPC	0.356 (0.68)	0.264 (0.41)	-1.138** (2.03)	-0.407 (0.42)	0.923* (1.80)
	TINT	-0.010 (0.36)	-0.008 (0.31)	0.050* (1.95)	0.004 (0.11)	-0.005 (0.16)
RE	ΔRAILPC	0.305 (0.58)	0.264 (0.41)	-1.362** (2.44)	-0.747 (0.75)	0.923* (1.80)
	TINT	-0.007 (0.25)	-0.008 (0.31)	0.059** (2.29)	0.020 (0.49)	-0.005 (0.16)
FE	ΔRAILPC	-0.008 (0.01)	-0.068 (0.11)	-1.846*** (3.13)	-1.279 (1.09)	1.590*** (3.36)
	TINT	-0.010 (0.36)	0.005 (0.16)	0.077*** (2.90)	0.048 (0.92)	-0.058* (1.73)
RE-IV	ΔRAILPC					
	TINT					
FE-IV	ΔRAILPC					
	TINT					
OLS	ΔRAILPA	0.059 (0.13)	0.541 (0.77)	-0.939 (1.45)	-0.429 (0.42)	-0.476 (0.34)
	TINT	-0.004 (0.16)	-0.026 (0.92)	0.042 (1.38)	0.003 (0.09)	0.038 (0.46)
RE	ΔRAILPA	0.024 (0.05)	0.541 (0.77)	-1.235* (1.92)	-0.701 (0.86)	-0.476 (0.34)
	TINT	-0.002 (0.07)	-0.026 (0.92)	0.054* (1.80)	0.021 (0.60)	0.038 (0.46)
FE	ΔRAILPA	-0.419 (0.91)	0.015 (0.02)	-1.565** (2.32)	-1.183 (1.25)	1.032 (0.83)
	TINT	0.025 (1.02)	-0.006 (0.18)	0.069** (2.25)	0.049 (1.09)	-0.016 (0.21)
RE-IV	ΔRAILPA					
	TINT					
FE-IV	ΔRAILPA					
	TINT					
OLS	ΔROADPC	0.287 (0.78)	0.426* (1.93)	0.229 (1.52)	0.017 (0.05)	-0.533 (1.64)
	TINT	-0.003 (0.19)	-0.012 (1.21)	-0.003 (0.35)	0.013 (0.83)	0.037** (2.07)
RE	ΔROADPC	0.293 (0.79)	0.405* (1.80)	0.205 (1.39)	-0.116 (0.30)	-0.533 (1.64)
	TINT	-0.004 (0.23)	-0.011 (1.06)	-0.003 (0.35)	0.012 (0.61)	0.037** (2.07)

FE	ΔROADPC	0.381 (0.91)	0.352 (1.42)	0.182 (1.22)	-0.127 (0.28)	-0.413 (1.49)
	TINT	-0.014 (0.67)	-0.008 (0.68)	-0.003 (0.32)	0.009 (0.41)	0.026 (1.58)
RE-IV	ΔROADPC					
	TINT					
FE-IV	ΔROADPC					
	TINT					

OLS	ΔROADPA	0.278 (0.78)	0.442** (2.06)	0.191 (1.39)	0.001 (0.00)	-0.520* (1.69)
	TINT	-0.007 (0.40)	-0.013 (1.33)	-0.002 (0.22)	0.017 (1.03)	0.033* (1.95)
RE	ΔROADPA	0.294 (0.81)	0.426* (1.95)	0.149 (1.17)	-0.148 (0.36)	-0.520* (1.69)
	TINT	-0.008 (0.47)	-0.012 (1.19)	-0.000 (0.01)	0.020 (0.93)	0.033* (1.95)
FE	ΔROADPA	0.378 (0.94)	0.393 (1.64)	0.109 (0.87)	-0.163 (0.34)	-0.422* (1.65)
	TINT	-0.016 (0.76)	-0.010 (0.92)	0.002 (0.23)	0.019 (0.76)	0.028* (1.78)
RE-IV	ΔROADPA					
	TINT					
FE-IV	ΔROADPA			0.685 (1.40)		
	TINT			-0.032 (1.09)		

OLS	ΔRDQLPC	0.178* (1.73)	0.249 (0.94)	0.086 (0.61)	0.020 (0.09)	0.178 (0.81)
	TINT	-0.009 (1.07)	-0.006 (0.49)	0.007 (0.95)	0.006 (0.61)	0.002 (0.17)
RE	ΔRDQLPC	0.177* (1.70)	0.249 (0.94)	0.051 (0.37)	-0.136 (0.61)	0.178 (0.81)
	TINT	-0.009 (1.11)	-0.006 (0.49)	0.008 (1.07)	0.013 (1.09)	0.002 (0.17)
FE	ΔRDQLPC	0.180 (1.54)	0.206 (0.85)	0.015 (0.11)	-0.223 (0.84)	0.121 (0.60)
	TINT	-0.013 (1.45)	-0.006 (0.56)	0.009 (1.21)	0.018 (1.14)	-0.005 (0.41)
RE-IV	ΔRDQLPC					1.792** (2.53)
	TINT					-0.078** (2.17)
FE-IV	ΔRDQLPC					0.776* (1.86)
	TINT					-0.037* (1.74)

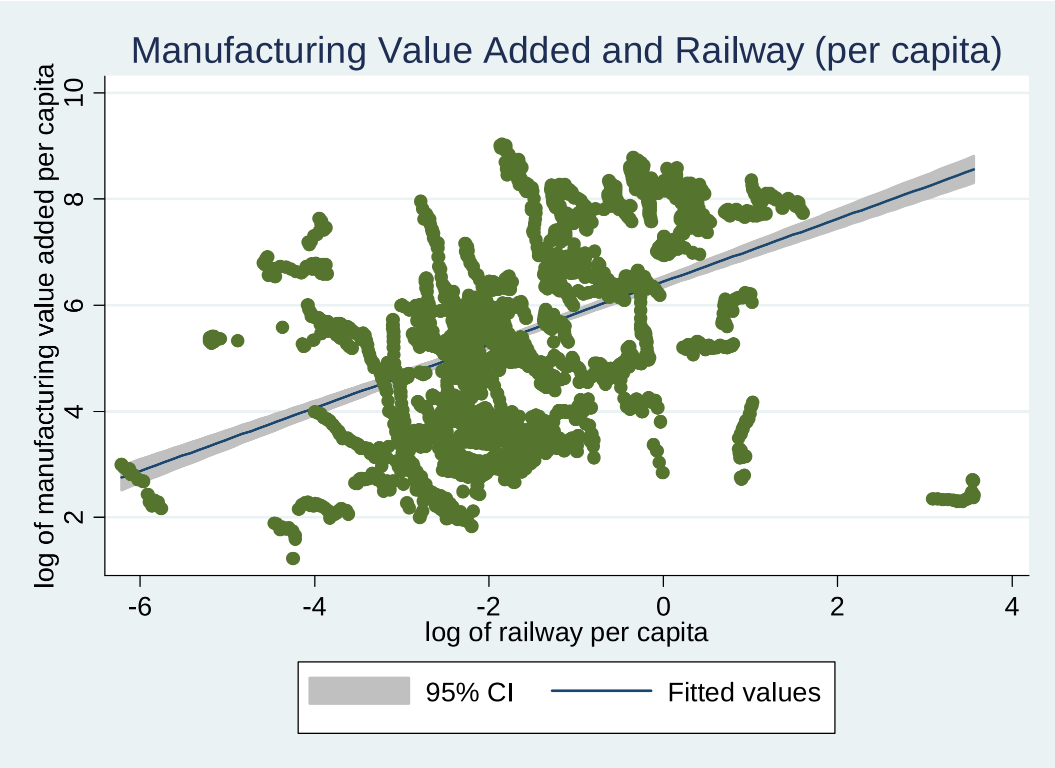
OLS	ΔRDQLPA	0.189* (1.92)	0.303 (1.10)	0.108 (0.78)	0.064 (0.28)	0.160 (0.75)
	TINT	-0.015* (1.73)	-0.008 (0.67)	0.005 (0.72)	0.002 (0.16)	0.001 (0.08)
RE	ΔRDQLPA	0.186* (1.86)	0.303 (1.10)	0.076 (0.57)	-0.055 (0.24)	0.160 (0.75)
	TINT	-0.015* (1.73)	-0.008 (0.67)	0.006 (0.86)	0.008 (0.61)	0.001 (0.08)
FE	ΔRDQLPA	0.175 (1.60)	0.244 (0.98)	0.040 (0.29)	-0.136 (0.51)	0.077 (0.39)
	TINT	-0.017* (1.79)	-0.008 (0.77)	0.008 (1.05)	0.013 (0.82)	-0.003 (0.23)
RE-IV	ΔRDQLPA					
	TINT					
FE-IV	ΔRDQLPA					0.837** (2.04)
	TINT					-0.040* (1.91)

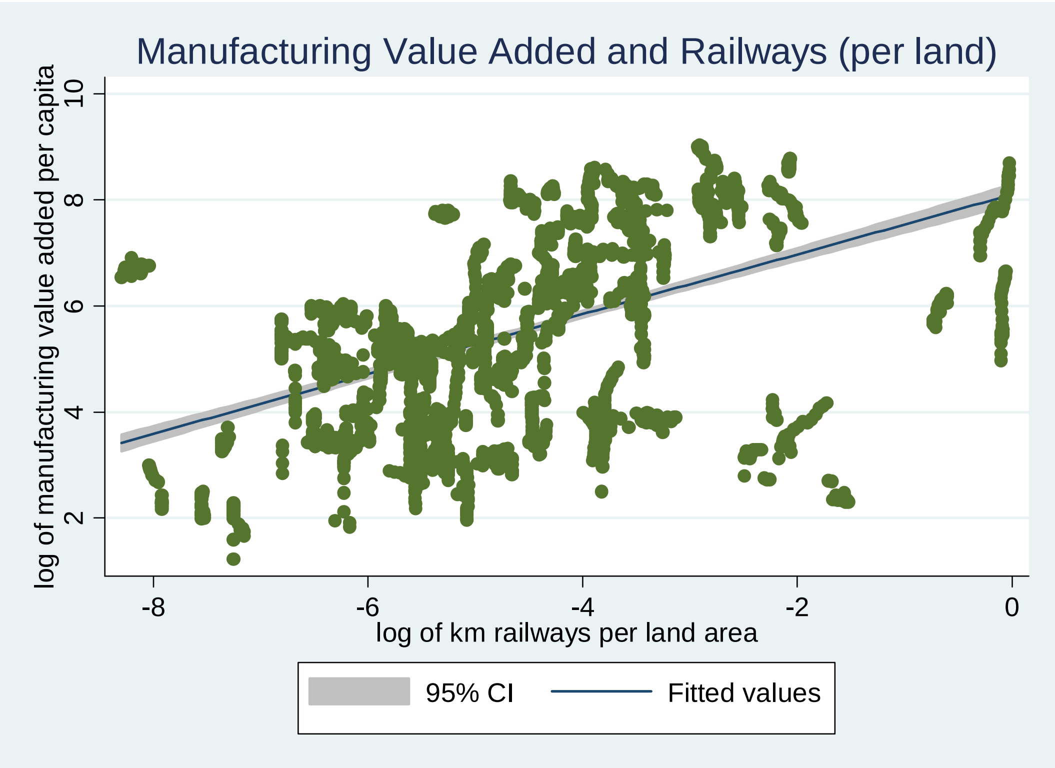
Note: All variables are in logs and absolute t-values in parentheses. ***, ** and * denote statistical significance at the 1, 5 and 10 per cent, respectively, small-sample correction carried out for FE-IV.
Δ = first difference operator.

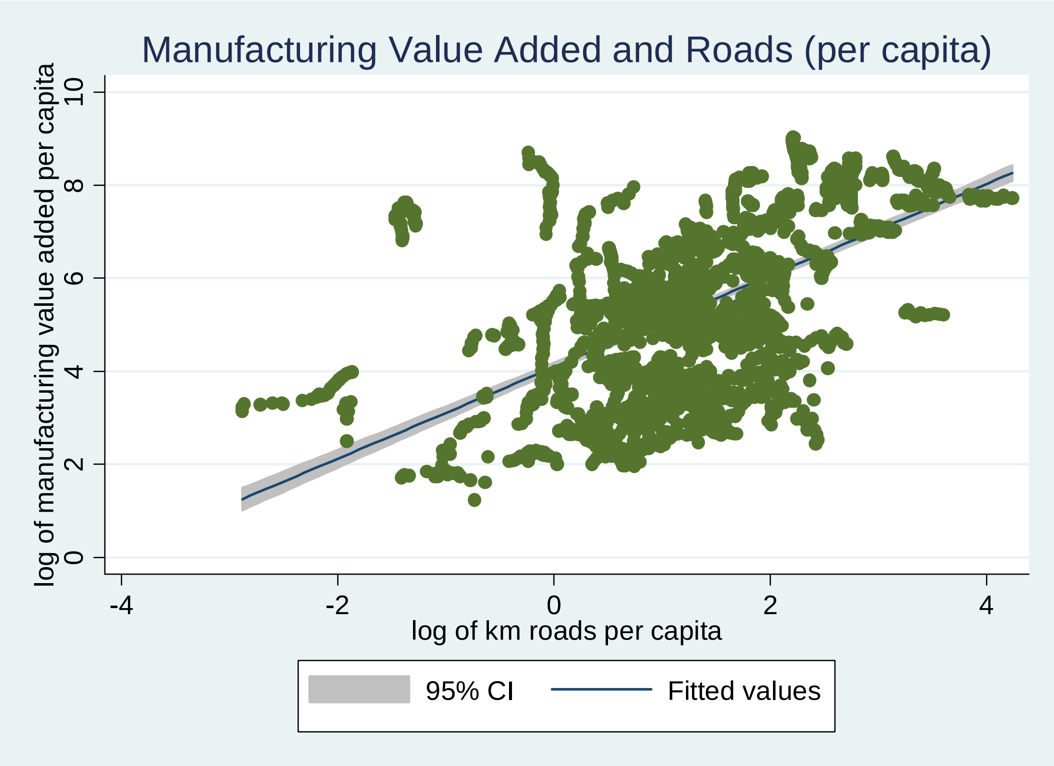
RAILPC = railways per capita, RAILPA = railways per land area, ROADPC = road per capita, ROADPA = road per land area, RDQLPC = paved road per capita, RDQLPA = paved road per land area.

Appendix I

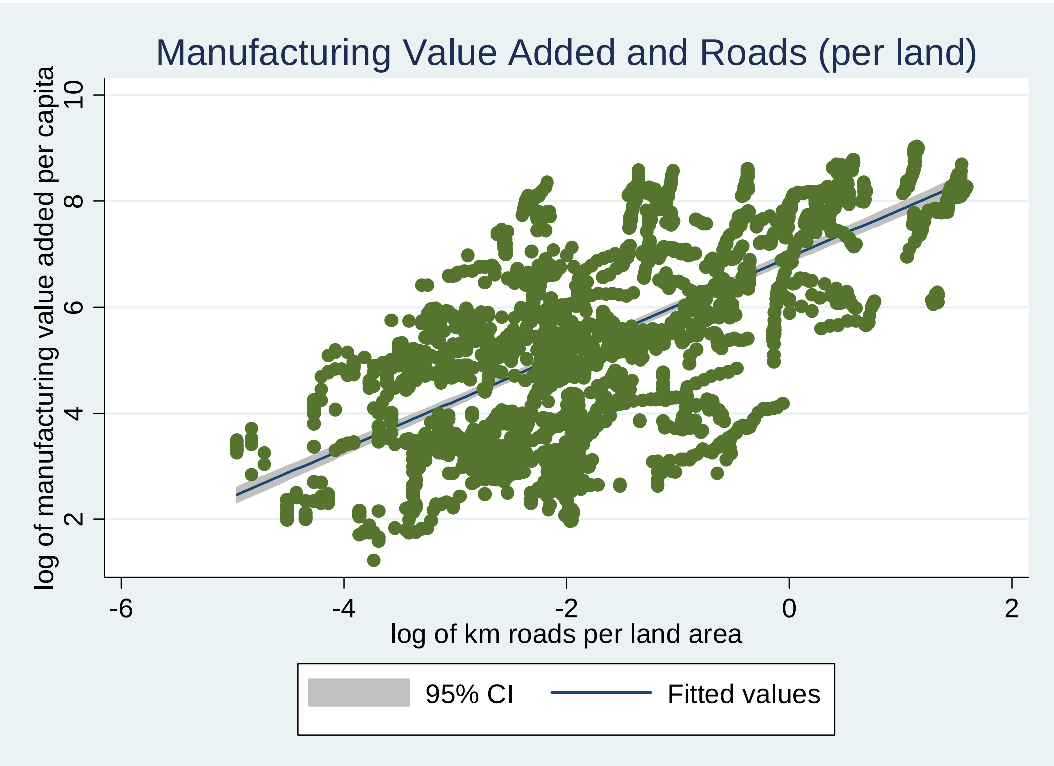
Two-way illustrations of manufacturing per capita and selection of RHS variables



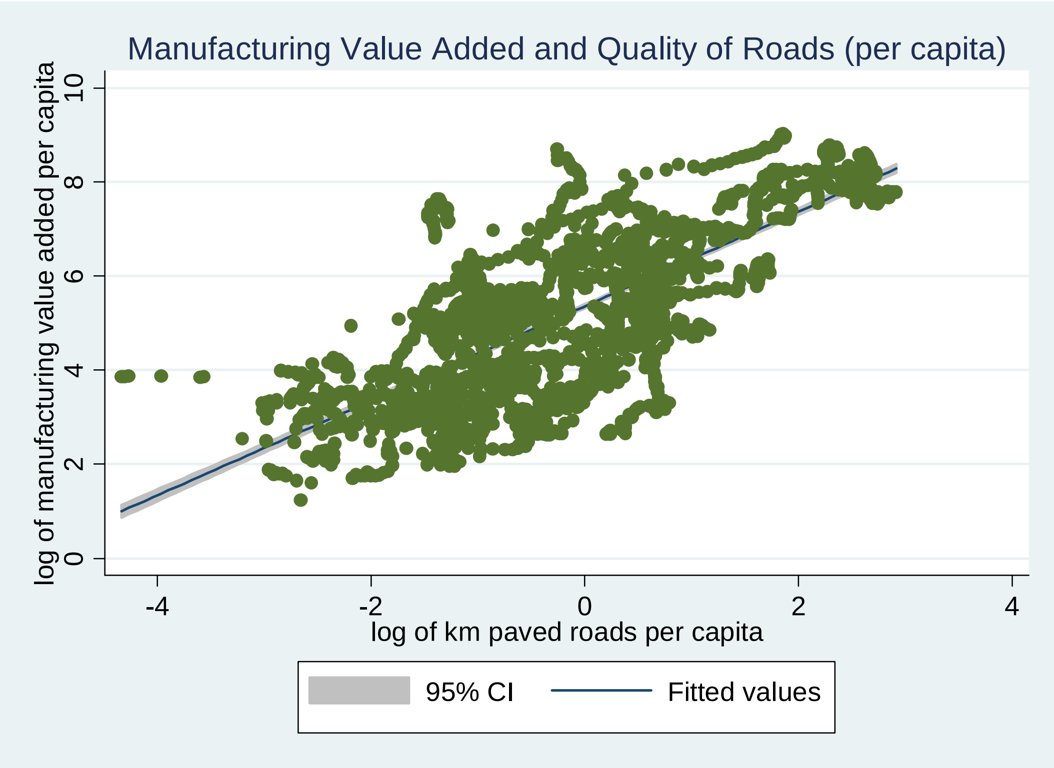


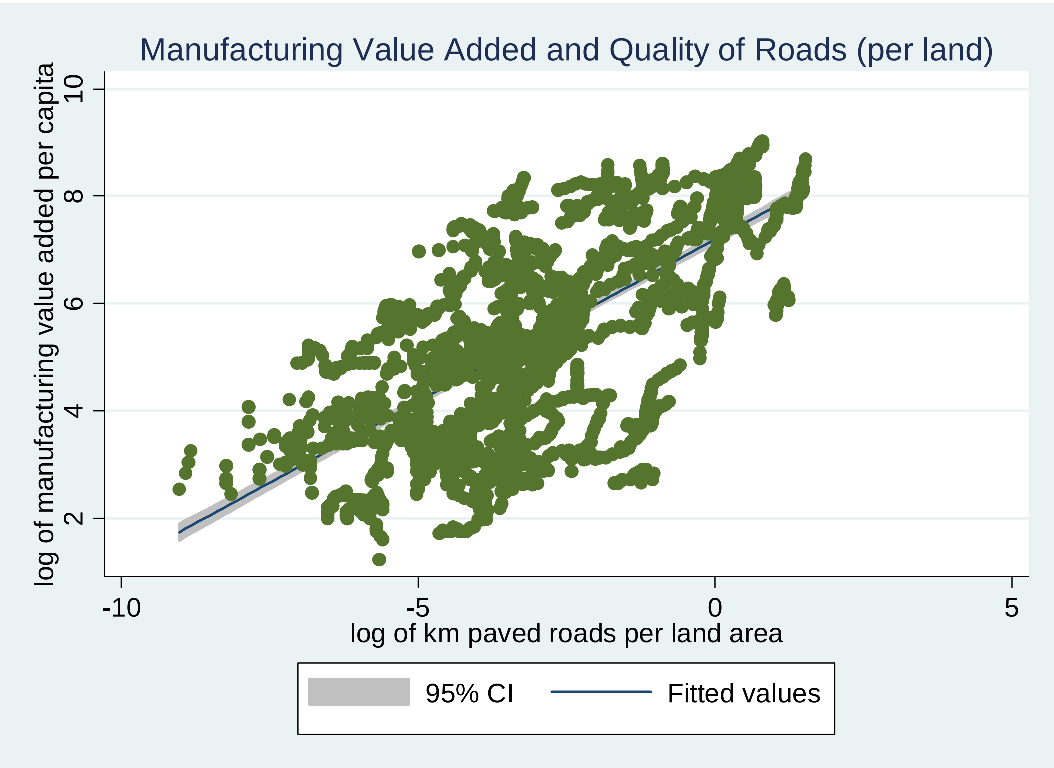


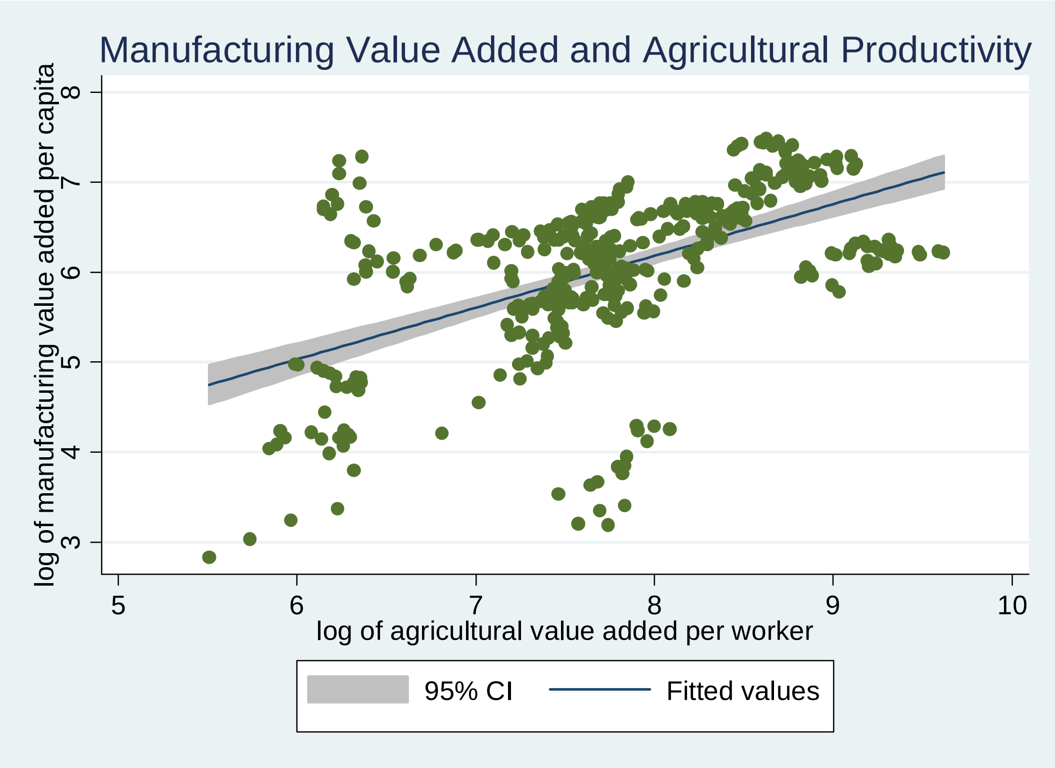
Manufacturing Value Added and Roads (per capita)
log of manufacturing value added per capita
0
2
4
6
8
10
-4
-2
0
2
4
log of km roads per capita
95% CI
Fitted values

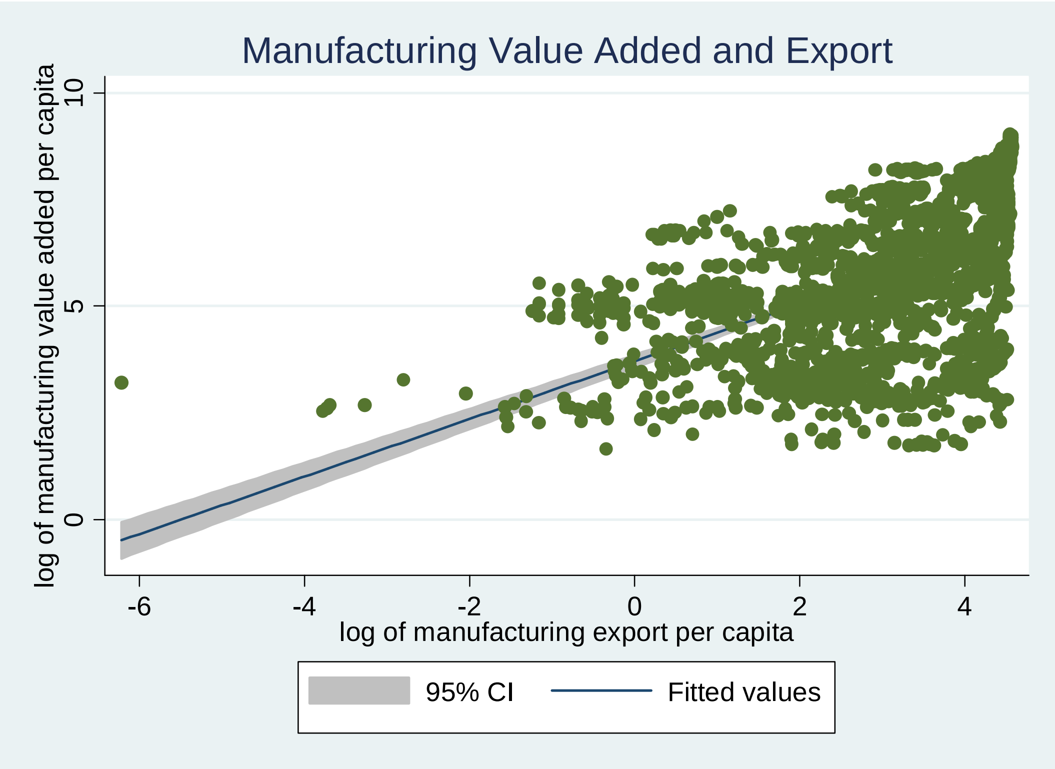


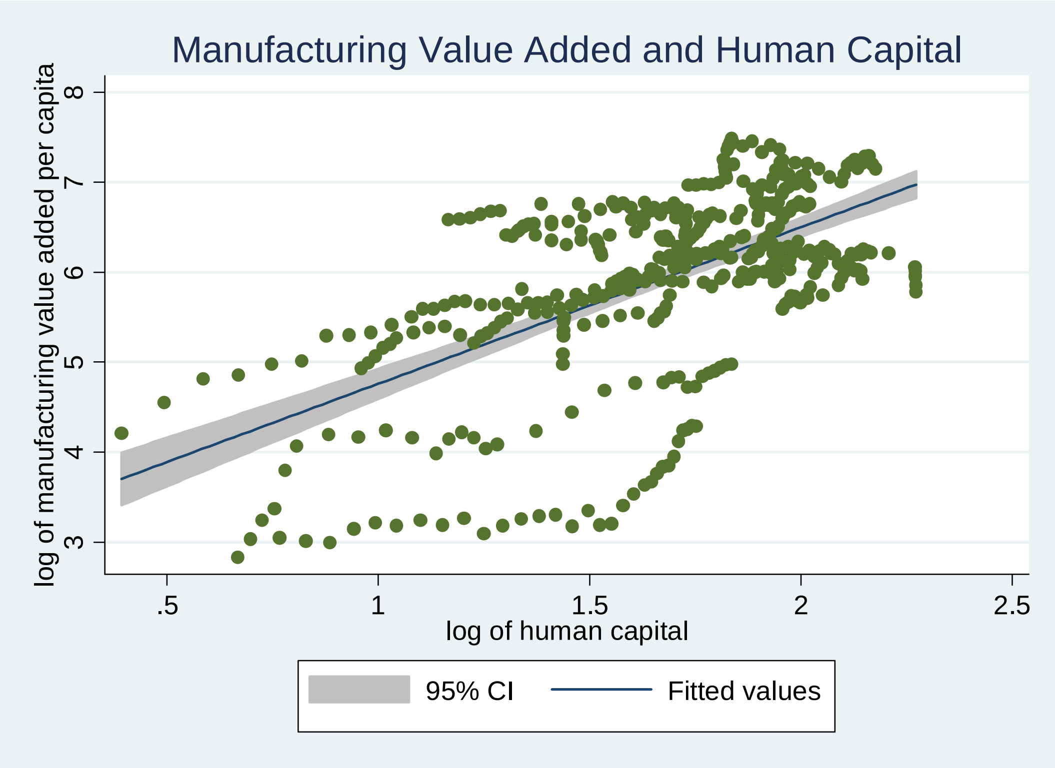
Manufacturing Value Added and Roads (per land)
log of manufacturing value added per capita
2
4
6
8
10
-6
-4
-2
0
2
log of km roads per land area
95% CI
Fitted values

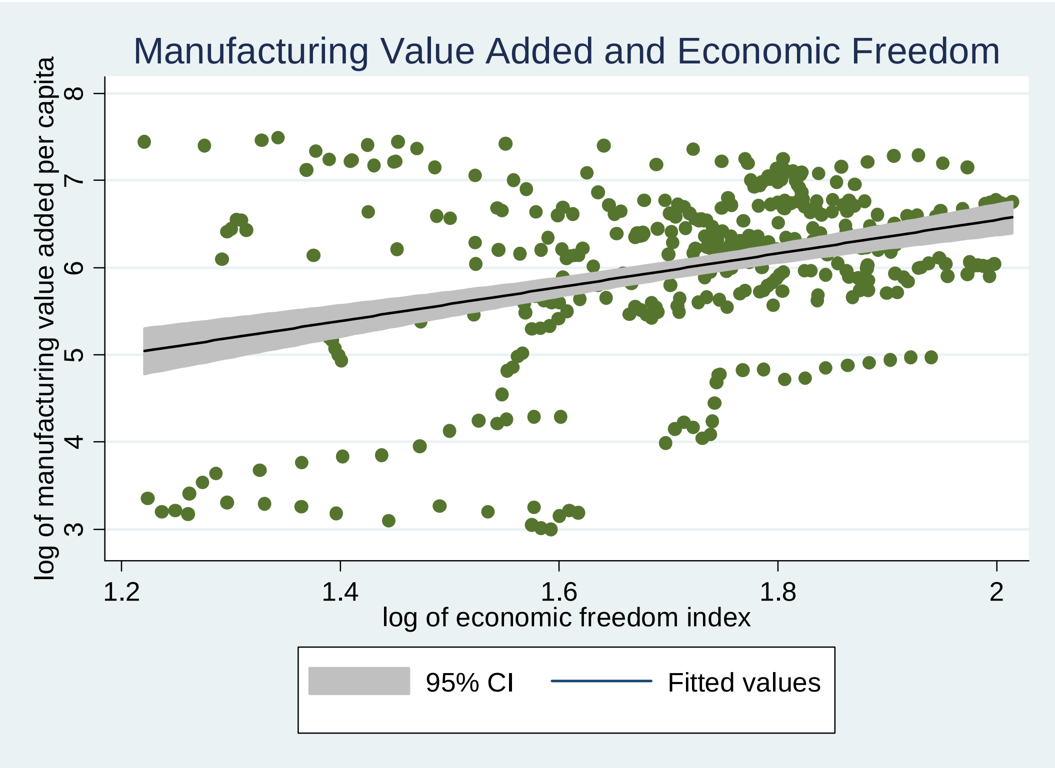

Manufacturing Value Added and Quality of Roads (per capita)
log of manufacturing value added per capita
0
2
4
6
8
10
-4
-2
0
2
4
log of km paved roads per capita
95% CI
Fitted values


Manufacturing Value Added and Quality of Roads (per land)
log of manufacturing value added per capita
2
4
6
8
10
-10
-5
0
5
log of km paved roads per land area
95% CI
Fitted values


Manufacturing Value Added and Agricultural Productivity
log of manufacturing value added per capita
3
4
5
6
7
8
5
6
7
8
9
10
log of agricultural value added per worker
95% CI
Fitted values

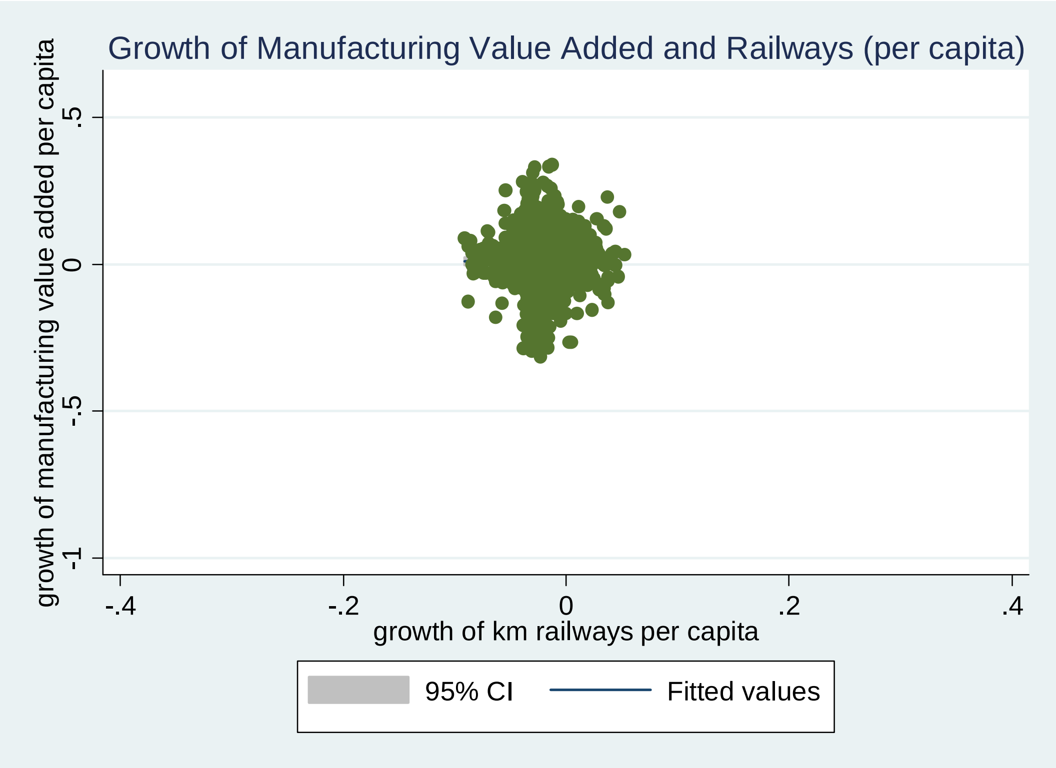

Manufacturing Value Added and Export
log of manufacturing value added per capita
0
5
10
-6
-4
-2
0
2
4
log of manufacturing export per capita
95% CI
Fitted values

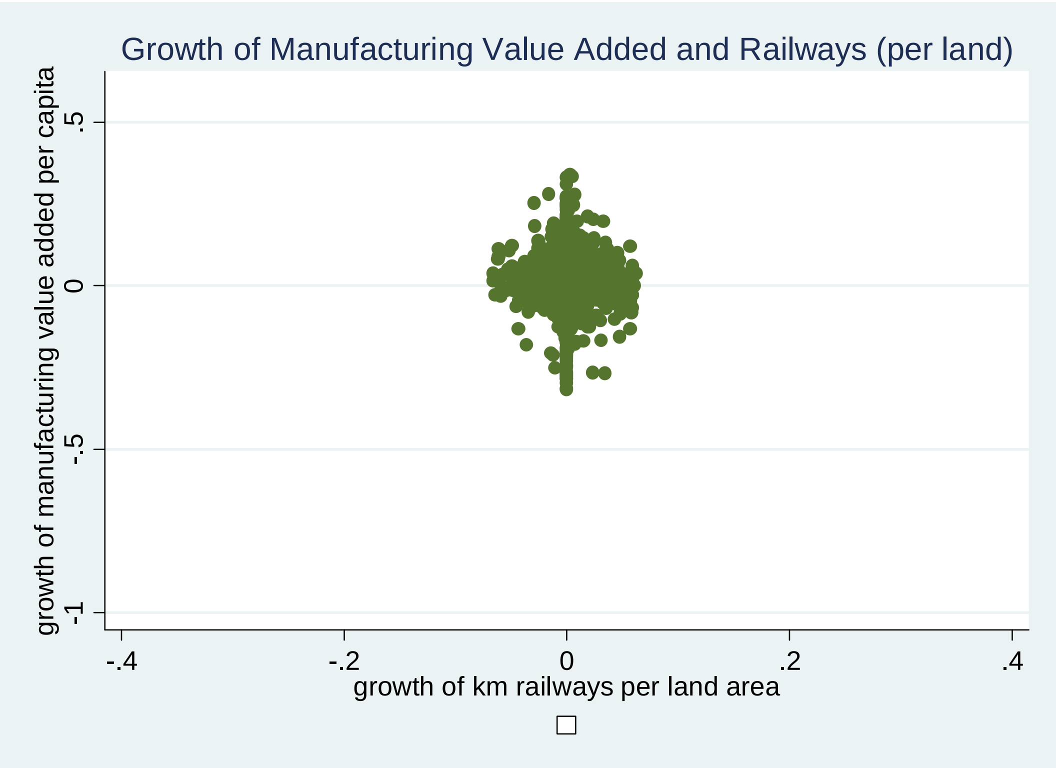

Manufacturing Value Added and Human Capital
log of manufacturing value added per capita
3
4
5
6
7
8
.5
1
1.5
2
2.5
log of human capital
95% CI
Fitted values

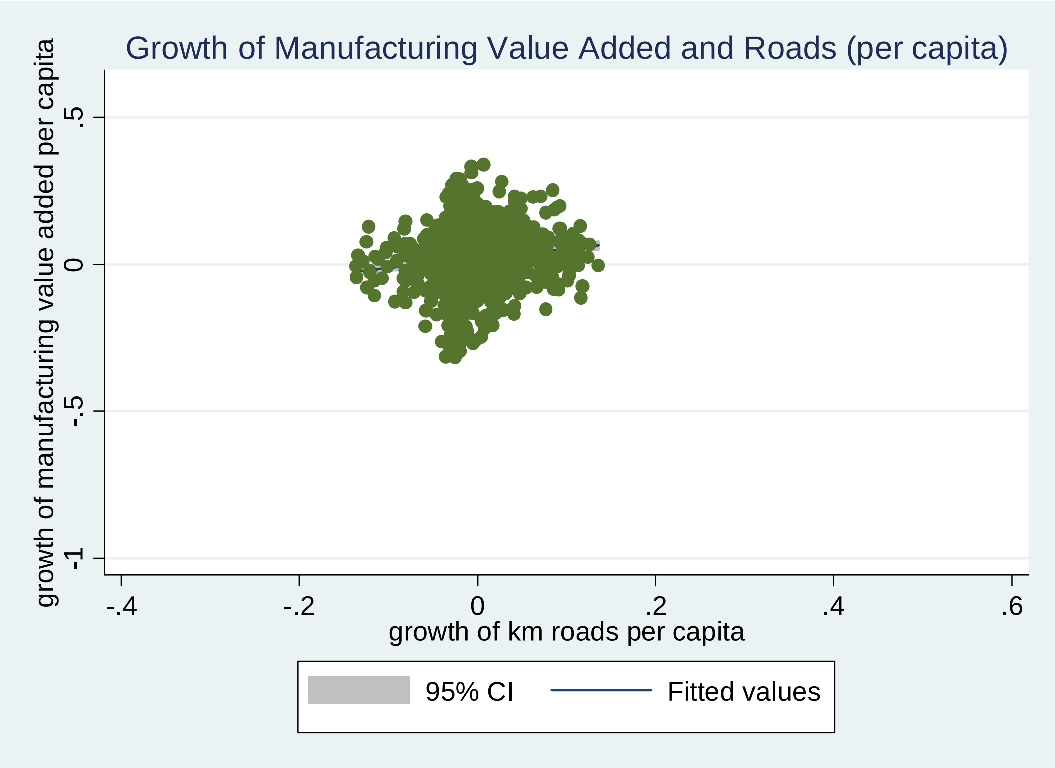

Manufacturing Value Added and Economic Freedom
log of manufacturing value added per capita
3
4
5
6
7
8
1.2
1.4
1.6
1.8
2
log of economic freedom index
95% CI
Fitted values

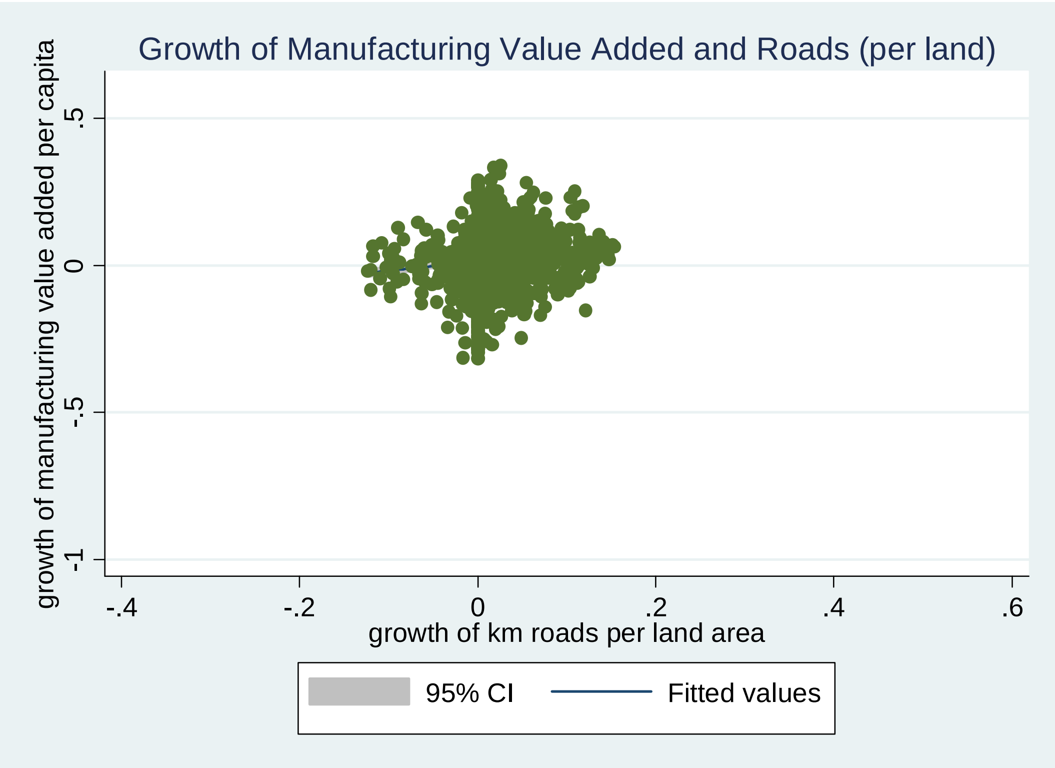
Appendix II

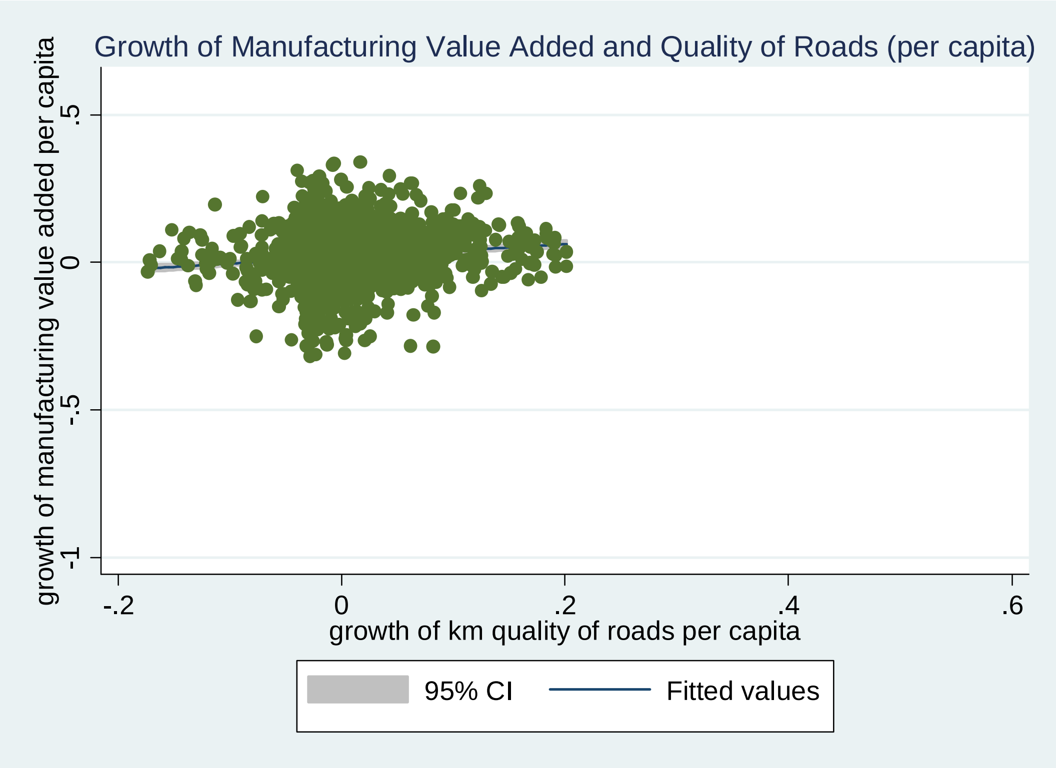
Two-way illustrations of change in manufacturing per capita and selection of RHS variables



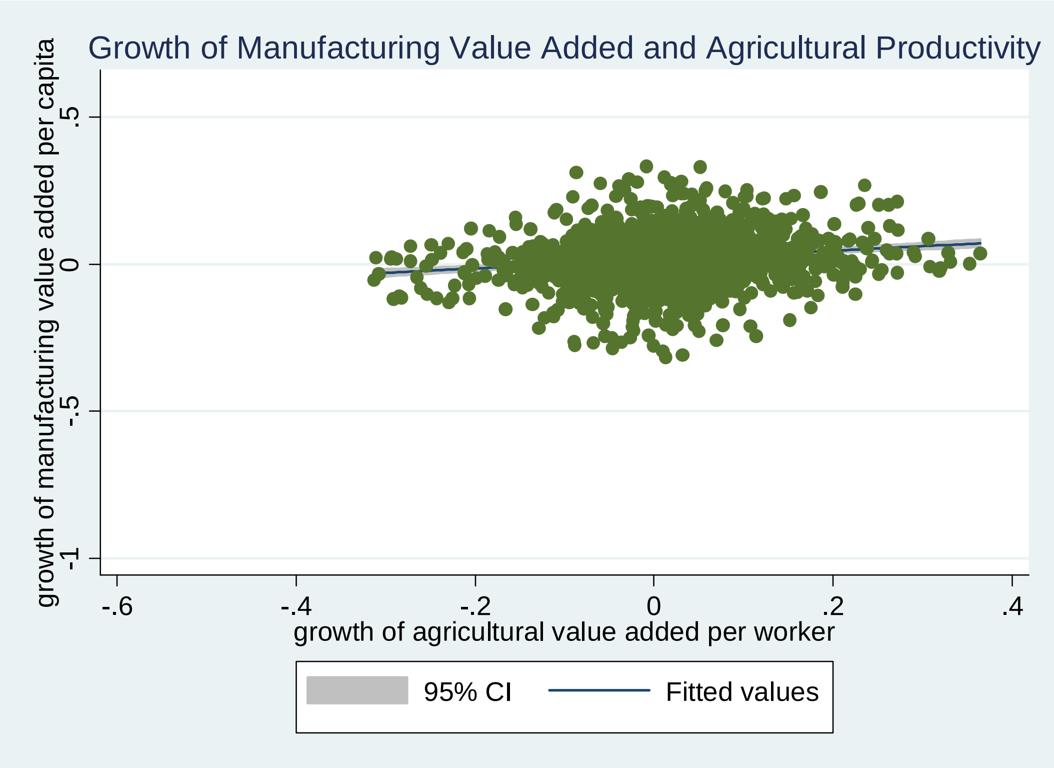



Growth of Manufacturing Value Added and Roads (per capita)
growth of manufacturing value added per capita
-1
-.5
0
.5
-.4
-.2
0
.2
.4
.6
growth of km roads per capita
95% CI
Fitted values

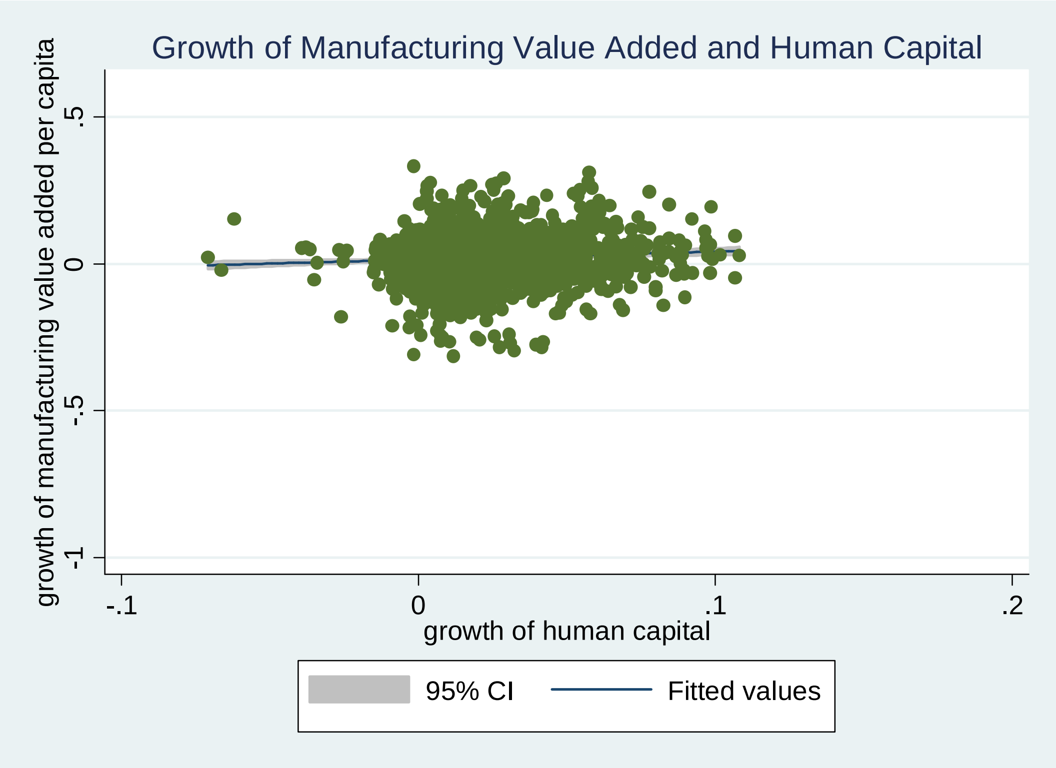

Growth of Manufacturing Value Added and Roads (per land)
growth of manufacturing value added per capita
-1
-.5
0
.5
-.4
-.2
0
.2
.4
.6
growth of km roads per land area
95% CI
Fitted values

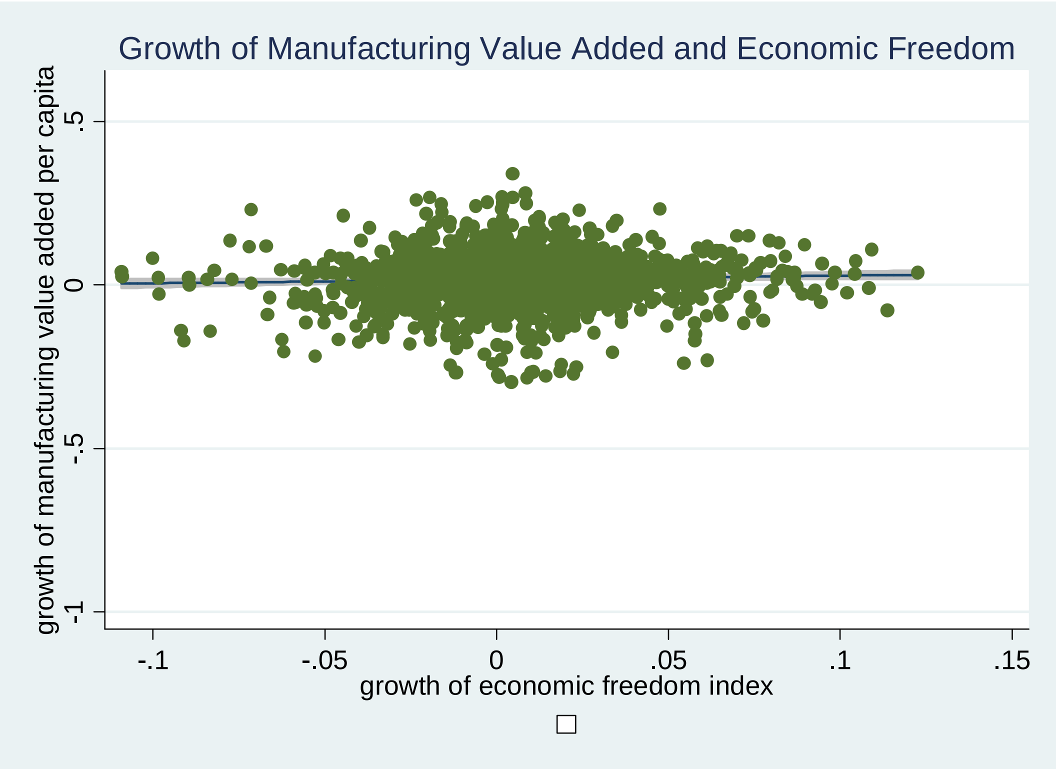

Growth of Manufacturing Value Added and Quality of Roads (per capita)
growth of manufacturing value added per capita
-1
-.5
0
.5
-.2
0
.2
.4
.6
growth of km quality of roads per capita
95% CI
Fitted values


Growth of Manufacturing Value Added and Quality of Roads (per land)
growth of manufacturing value added per capita
-1
-.5
0
.5
-.2
0
.2
.4
.6
growth of km quality of roads per land area
95% CI
Fitted values


Growth of Manufacturing Value Added and Agricultural Productivity
growth of manufacturing value added per capita
-1
-.5
0
.5
-.6
-.4
-.2
0
.2
.4
growth of agricultural value added per worker
95% CI
Fitted values


Growth of Manufacturing Value Added and Manufacturing Exports
growth of manufacturing value added per capita
-1
-.5
0
.5
-4
-2
0
2
4
growth of manufacturing exports per capita
95% CI
Fitted values


Growth of Manufacturing Value Added and Human Capital
growth of manufacturing value added per capita
-1
-.5
0
.5
-.1
0
.1
.2
growth of human capital
95% CI
Fitted values


Growth of Manufacturing Value Added and Economic Freedom
growth of manufacturing value added per capita
-1
-.5
0
.5
-.1
-.05
0
.05
.1
.15
growth of economic freedom index

Printed in Austria
V.10-50048—February 2010—200

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