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One Model fits all? Determinants of Transport Costs across Sectors and Country Groups

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One model fits all?

Determinants of transport costs across sectors and country groups*

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Abstract

We show with the aid of pooled OLS estimations that investments in improved road infrastructure have the potential to significantly reduce transport costs. However, this result can only be clearly confirmed for industrial countries and is of primary importance for production and transportation of agricultural goods. For developing and transition countries we find other determinants such as weather conditions to be more important in determining transport costs. A key variable, especially in these countries, is corruption. At very high levels corruption has the potential to prevent positive effects from roads on transport costs or to even reverse them.
This paper contributes to the literature on infrastructure investment by introducing and applying an internationally comparable measure of transport costs which can be calculated for a large and growing number of countries. We isolate important determinants of transport costs and provide insights into international and sectoral differences concerning the impact of roads on transport costs. We conclude that investment in transport infrastructure can have substantial positive effects especially on agricultural production and the efficient marketing of agricultural products but only if specific conditions are in place.

JEL Classification: O11, R42, O18
Keywords: Infrastructure, Transport networks, Transport costs, Agriculture, public investment, development

*Preliminary version, comments are most welcome.

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1. Introduction

Investment in infrastructure is frequently seen as a promising path for growth and development. Based on the experiences with large infrastructure investments in industrial countries like e.g. the first transcontinental railroad in the U.S. finished in 1869, infrastructure projects are widely considered to induce large growth effects. However, the magnitude of the estimated effect differs quite substantially.

Classic studies in the field of economic history like Jenks [1944] or Fishlow [1965] for the United States and Fremdling [1977] for Germany argue that the connection of markets through railways had a massive influence on the industrialisation of the respective countries. Comparable studies also exist for the initial construction of motorways in industrial countries. In modern industrial economies infrastructure networks are still seen as important prerequisites for regional development. This is for example reflected in the large scale infrastructure programs after German reunification and also in the inclusion of infrastructure into the aims of the Lisbon strategy:[1]

> Establishing an efficient trans-European transport network (TEN-T) is a key element in the relaunched Lisbon strategy for competitiveness and employment in Europe. If Europe is to fulfil its economic and social potential, it is essential to build the missing links and remove the bottlenecks in our transport infrastructure, as well as to ensure the sustainability of our transport networks into the future. (European Commission)

The assumption that infrastructure reduces transport costs is also included in many gravity models in international trade. Infrastructure is included as an explanatory variable in some of these models which implicitly assumes that there is an influence of infrastructure on trade costs.

Policy initiatives such as the WTO's *Aid for Trade* program or the World Bank's *Infrastructure Action Plan* emphasize the importance of infrastructure also for developing countries. This political emphasis on infrastructure reflects the widespread belief that the observed positive effects from infrastructure in developed countries apply to developing countries as well.

The literature usually argues that improvements in the road network reduce transport costs and transport times. The studies on Americas railways distinguish three types of effects from infrastructure improvements: the direct effect on transport costs which is argued to reduce transaction costs and thus increase the volume and number of transactions, the *backward linkage* through increased demand for resources and factors needed for

[1] Source: European commission http://ec.europa.eu/transport/infrastructure/index_en.htm

infrastructure construction and the *forward linkage* effect which summarizes the induced additional economic activities due to the presence of infrastructure. The importance of the direct cost reducing effect (which is also a prerequisite for *forward linkage* effects) has been stressed in many subsequent studies.

Reduced transport costs are e.g. mentioned as important results from infrastructure investment in developing countries in Escobal & Ponce [2002] and Teravaninthorn & Raballand [2009]. However, even for industrial countries concrete estimations for the travel cost reduction from better roads are scarce. This is partly due to the fact that time series based studies for distinct countries cannot provide a proper counterfactual. There are a number of studies in the international trade literature that quantify the tariff equivalent costs of poor roads on international trade but these cannot provide any insight concerning *intranational* transport and often focus on industrial countries alone [See Yeats, 1980; Limao & Venables, 2001; Portugal-Perez & Wilson, 2008, e.g.]. Evidence on the effects of better roads in developing countries is mixed.[2] Jensen [2009] investigates the infrastructure-transport cost link in a recursive-dynamic CGE model and assumes a decreasing influence of additional roads on the transport margin.

This paper contributes to the existing literature by developing and applying an internationally comparable measure of transport costs and estimating the effect of the length of transport ways on this measure across countries. Pooled estimations of the influence of transport network density on the transport margin show that better transport networks reduce transport costs. The effect is stronger for agricultural sectors compared to a weighted measure for all sectors. The observed effect from infrastructure on transport costs differs substantially across country groups. It cannot be confirmed unconditionally for developing and transition countries. In their case, other determinants such as weather conditions and the level of corruption have a strong influence on transport costs as well. For middle and low income countries the results are hardly robust and somewhat sensitive to the inclusion of additional control variables. Most importantly, in low and middle income countries the effectiveness of road infrastructure strongly depends on the level of corruption. In highly corrupt countries the effect might be reversed and a higher level of infrastructure comes along with higher transport costs.

2. Literature and theoretical background

The literature on the effects from infrastructure investments states that improving the length and quality of roads and railroads would lead to higher output and lower poverty.

[2] See Estache [2006] for a comprensive survey of the literature.

The reasoning behind this is a combination of different positive effects. Roads in general and paved roads in particular improve the connection between producers, markets and consumers. Enhancements of the roads and railroads of a country should hence lead to a more efficient allocation of goods and services.

Most macroeconomic studies on the effects of infrastructure follow the so-called production function approach based on Aschauer [1989] who applied the method to U.S. time series data. These studies estimate a national production function where GDP or growth depend not only on labour, capital and technology but also on public capital. Public capital is normally measured using the perpetual inventory method, i.e. aggregating past investment flows. This approach has been applied to developed and developing countries, to time-series, cross-section and panel data and there seems to be a consensus on the positive effect from public capital on output even though the magnitude of this effect is disputed. [See e.g. Hulten, 1996; Ram, 1996]. Hulten [1996] finds that the effect of public capital on growth is much lower if the sample comprises developing countries. He argues that this is due to less efficient planning and use in these countries. Also Aschauer [2000] states that it might be crucial whether present infrastructure is used efficiently. Still, the methodology is only capable to investigate the effect of public capital as an entity instead of the effects of better transport networks in particular. This caveat is mentioned e.g. by Calderon & Serven [2008].

In addition to the considerable macroeconomic literature there exists a variety of country and case studies evaluating specific projects or programmes. Examples for industrial countries are: Holl [2007]; Linneker & Spence [1996] and Vesper & Zwiener [1991]. Recent examples for developing countries are Olsson [2009] who analyses the Philippines, Escobal & Ponce [2002] who compare three African countries, Fan *et al.* [1999] for India or Fan [2008] for Uganda. For all of these countries it has been found that especially rural roads provide an instrument to reduce rural poverty and promote growth but only Olsson [2009] and Escobal & Ponce [2002] try to establish a more concrete chain of effects that explains the overall positive effects. While Olsson [2009] gives theoretical reflections on this, Escobal & Ponce [2002] estimate the effect of the road status on travel times and do not find a robust effect across the three countries in their sample.

Olsson [2009] argues that the positive aggregate effect of better and longer roads is based on an improved cost efficiency in transporting goods to markets. The lower transport costs are explained by shorter travel times combined with less loss on the road, direct market access even for small scale producers, reduced information asymmetries and quicker adaption to changes in supply and demand. In addition, Olsson [2009] expects that it is likely that the economy undergoes structural changes as technologies spread more easily across the country.

While there exists a lot of empirical support for the general idea that improved roads lead to higher production and welfare, there is only a very limited number of studies that directly investigate the infrastructure - transport cost link. The link has been investigated for large past infrastructure projects in distinct countries like the U.S. railways or the Eastern German motorways but to our knowledge an international comparison of the transport cost effects of infrastructure investment is still due. This might be mainly due to the fact that data on transport costs across a large number of different countries is not available especially not for developing and transition countries.

In contrast Escobal & Ponce [2002] and Teravaninthorn & Raballand [2009] focus on developing countries and especially on Africa. They apply a completely different methodology compared to most studies for industrial countries.

The recent literature is rather vague about the exactly quantified relation between increased expenditure on infrastructure and the effect on transport costs. For developing countries there exist only very few studies. In a case study of several international transport corridors in Africa Teravaninthorn & Raballand [2009] find that an improvement of the roads from "fair" to "good" reduces the transport cost by approximately 15%. Other concrete cross-country estimations that include national transport costs and not only international transport costs do not exist to our knowledge.

Summarizing the recent literature on infrastructure in developing countries Estache [2006] concludes that "the knowledge gap is not a small one".

3. Econometric design

Against the background of the described literature this paper attempts to quantify the effect from better and longer roads on transport costs directly and investigate whether there exist systematic differences between industrial countries and developing and transition countries. As an internationally comparable measure of transport costs we will use the sectoral spending on transportation relative to overall sectoral production costs and aggregate this over comparable sectors. Information on sectoral spending on transportation can be obtained from social accounting data. Social Accounting Matrices (SAMs) are available for a large number of countries and for several years and provide detailed sectoral information on the demand for transport services.[3] This allows to build a dataset

[3] The results found with this measure might also be useful in the specification of SAM-based CGE models such as Jensen [2009].

on international transport spending. The underlying SAMs differ in their level of disaggregation but can be aggregated to a comparable structure.

In a pooled estimation for 64 countries from all over the world and three periods we investigate the effect of transport density on these transport margins. This is a straightforward way to test the aforementioned theoretical reflections.

We estimate the following equation:

$$ln(m_i) = \alpha + \beta\, ln(transport_i) + \gamma\, controls_i + \delta\, dummys_i + u_i \qquad (1)$$

As dependent variable we use sectoral spending on transport services relative to sectoral output, i.e. the transport margin (m_i). We calculate this weighted margin from input-output data both only for agricultural sectors and over all sectors, we use sectoral output as weights.

The transport margin thus comprises all elements of transport costs that have been reported as spending on road, air and water transportation, transportation related services and maintenance of transport vehicles. It indirectly covers wages paid to the labor and capital involved in transportation. The measure is not able to account for indirect costs of long transport ways such as the loss of perishable goods or the foregone profit due to the time spent on the road that could not be used productively (if not comprised in labor cost in transportation). As we calculate the cost measure relative to total sectoral cost we consider it highly comparable across countries even if production technologies differ substantially.

Our main independent variable of interest is the road network density ($transport_i$) measured here as the length of paved roads in km per surface in km^2.[4] We expect that higher transport network densities are associated with lower transport margins. In addition, we expect this effect to be more pronounced in agricultural sectors.

Several other variables should have an impact on transport costs. The GDP per capita ($gdpc_i$) as a proxy for the development of the economy but also for the overall transport demand is included as explanatory variable, too. One would expect that with higher overall transport demand, costs should decrease due to economies of scale. On the other hand if the level of technology is very low, an increasing GDP could also induce higher transport costs if transport is a very scarce service. This ambiguous ex ante expectation

[4]As an alternative measure for transport infrastructure we use paved roads and railroads. This does not have a substantial impact on the results.

on the influence of GDP on transport costs might lead to a non-linear influence. We therefore test for non-linearity in GDP by including $gdpc^2$.

In addition we control for the degree of urbanization ($urban_i$) as a measure of dispersion of the market participants. Intuition suggests a negative coefficient for urbanization over all sectors. As a higher degree of urbanization implies shorter transport ways and thus lower transport margins. Thus, the opposite is true in agricultural sectors: If the major part of the population lives in towns, food has to be carried long distances from the production site to the consumers.

Moreover, we include the population density ($popdens_i$), measured as persons per km^2. On the one hand a higher population would mean higher transport requirements for transport of persons and thus imply a positive coefficient. On the other hand a smaller population might be spread across wide surfaces and thus need more transport which also induces higher transport costs.

Climate conditions have a strong influence on both, the status of present roads and the possibility to use them. For this reason we include two climate variables: a temperature index and the yearly precipitation. The temperature index is calculated by adding up the squared maximum and minimum temperatures in degree Celsius for the respective year. Precipitation is measured in total mm per m^2 per year.

As we will focus part of our investigation on transport costs in agricultural sectors we include the fraction of land dedicated to agricultural use ($agrland_i$) in these estimations. A higher share of agricultural land is expected to increase the efficiency of transport in these sectors and thus decrease transport costs.[5]

Some studies on public investment argue that the efficiency of the use of public capital is very important and that part of public investment are never used productively due to corruptive elites. [See Hulten, 1996; Aschauer, 2000] For this reason we include *transparency international*'s *perceived corruption* index as explanatory variable in some estimations. The index is defined between 0 and 10 where low values of the index are associated with very high levels of corruption.

As the sample comprises different countries from all over the world, we include sets of dummy variables to control for structural differences between country groups. We al-

[5]We tried to include the number of motor vehicles per 1000 persons as a proxy for transport technology, however, this measure is only available for a very limited number of periods and countries and thus the results are not reliable. The results are shown in table 11.

ternatively include dummies for income groups, for geographical regions and for OECD member status.

We run estimations both for the margin in agricultural sectors only and for the weighted margin aggregated over all sectors. All estimations have been done using pooled data and OLS with heteroscedasticity-corrected standard errors (White procedure). Given the frequent and systematic missings a fixed effects estimation with cross-section fixed effects is not possible. Instead we include country-group fixed effects and time fixed effects. Time fixed effects, however, have never been significant and thus results are not reported here.

3.1. Data

We construct a panel data set from various sources.[6] The panel contains data for 64 countries and 3 years (1995, 2000, 2005). The panel is highly unbalanced and missings are systematic (OECD countries usually have a full set of observations whereas part of the non-OECD countries have only 2 or even only 1 observation). The explanatory variables are available for all countries and nearly all years. In contrast, Social Accounting Data is not frequently surveyed in all countries. For most developing and transition countries only one SAM is available.[7] In total we have 135 observations.

The data on transport margins has been collected from input-output-tables from different sources, mainly the International Food Policy Research Institute (IFPRI), Eurostat and the OECD. Data on road and rail road length as well as the control variables are from the World Development Indicators (WDI) Database. The country classification in income groups follows the World Bank classification. The regional groups are chosen as in Fay & Yepes [2003]. Tables 3 and 4 show descriptive statistics.

The spending for transport ranges between 0.4% and 15 % of sectoral production costs, 3.5 % on average in agricultural sectors and between 1 and 15% over all sectors, 6% on average. The countries in our sample have on average 788 m of paved roads per km^2 of surface where the lowest transport network density is at only 3m/km^2 and the highest at 6086 m/km^2. The GDP per capita lies between 254 US-$ and 51,934 US-$. On average 168 persons live on one km^2 of surface. The least concentrated country is populated by only 2.4 persons/km^2 and the most densely populated has over 3100 persons on the same surface. On average more than half of the population lives in towns, only 12% in the most rural country and over 97% in the most urbanized.

[6] A detailed overview of the different data sources is included in table 2 in the appendix.

[7] The availability of SAMs also determines the total number of countries, we can only use Social Accounting Matrices where transportation is explicitly included and not aggregated with trade services.

The climate conditions vary substantially across the countries. The squared temperature lies between 7 and 7000 degrees Celsius. The maximum mean temperature is at about 32°C, the minimum mean temperature is at about -11°C.

Table 3 here.

The sample consists of 64 countries of which 29 are high income countries, three Eastern Asian and three Southern Asian countries, nine eastern European and Central-Asian countries, twelve Latin American countries, one Middle East and seven countries from Sub-Sahara Africa. Given the fact that the sample is biased in favor of high income countries (app. 60% of the observations are from high income countries) we include income group dummies to control for this and estimate country-group wise in addition to the pooled estimation.

The observations with very low margins, very high temperature and very low degree of urbanization have been excluded from the relevant regressions after distributional tests.

Table 4 here.

4. Results

4.1. Pooled estimation

Table 5 summarizes the regression results for different specifications with the transport margin in agricultural sectors (m_{ag}) as dependent variable. This margin in agriculture should be more sensitive to bad roads compared to m_{all} which is the weighted average of the transport margins in all sectors[8]. All variables have been used in natural logarithms such that the results can be interpreted as elasticities.[9]

Table 5 here.

The regressions clearly show that for the complete sample an increased availability of roads significantly reduces the transport margin in agricultural sectors. This effect is robust in a number of different specifications. The sign remains negative across the different estimations. However, the effect is only significant in the first two specifications and in those specifications in which we control for distinct country characteristics such as the the income group classification or the geographical location.[10] All these may be

[8]Results for all sectors are described in table 6.

[9]In addition, the use of logarithms significantly reduces the number of outliers which is important here, given the rather small sample and the fact that there is a large difference in magnitude between the different variables (GDPC has much higher absolute values than the other variables).

[10]The coefficient ist also significantly negative if we control for the level of education in the labor force. The education variable itseld is, however, not siginificant. This result is shown in table 11 in the appendix.

interpreted as indicators that clearly differ between industrialized and developing countries. The estimated elasticity of the transport cost measure with respect to changes in the road density lies in absolute terms between 0.077 and 0.334.

The other explanatory variables clearly add explanatory power to the estimation but are mostly insignificant. We find a fairly robust positive relationship between the degree of urbanisation and transport costs in agricultural sectors, which is related to the fact that in highly urbanised countries the distance between production site and sales market for agricultural products is highest.

Results for the impact of GDP per capita are ambiguous. In order to check whether this is due to a non-linear relationship between GDP transport costs, we add $GDPC^2$ in estimation (a2). The coefficients for $GDPC$ and $GDPC^2$ have opposing mathematical signs, which is an indicator for a non-linear relationship between the dependent variable and the GDP per capita, however none of the two coefficients are significant and the squared term adds only little explanatory power.[11]

The inclusion of the climate indicators seems to be important as these significantly increase the explanatory power even though they are only significant in equation (8). Both high temperatures and high quantities of precipitation increase transport costs, which is quite intuitive as these extreme weather conditions hinder transport even if roads are appropriate.

A high share of agriculturally used land is associated with slightly lower transport margins in agriculture, supposedly due to economies of scale. The effect is not significant in the complete sample.

The two dummy variables for low and middle income countries are negative and the low income dummy is highly significant. If these dummies are alternatively split into five regional dummies for the low and middle income countries, only the Latin America dummy and the South Asia dummy are significant and the overall explanatory power of the estimation is lower. However the significance of these dummies for income groups or geographical location is a strong indication for a substantial difference between high income countries on the one hand and developing and transition countries on the other hand.

One possible explanation for differences in transportation costs between high income and middle and low income countries, apart from the climate (which adds some explana-

[11] See table 11 in the appendix.

tory power but is not significant), might be that high levels of corruption lead to higher transaction costs and longer transport times due to frequent controls on the way. Indeed corruption is strongly negatively correlated with GDP per capita (see figure 1) and might thus explain the significance of the income dummies if it plays a role in determining transport costs.

In order to take this into account we include *transparency international's perceived corruption index* into estimations (9) and (10). The inclusion of the index increases the adjusted R^2 by 1.7 percentage points. The coefficient has the expected negative sign[12] but is not significant.

As we believe that the effectiveness of roads might be conditional on the absence of corruption we include an interaction term between the corruption index and the road density in the last specification. Surprisingly, this strongly affects the results. The explanatory power rises, the coefficient of road density switches from significantly negative to insignificantly positive and the coefficient of the corruption index increases and is now significant, too. The positive coefficient for road density indicates that at very high levels of corruption (i.e. corruption index = 0) an increase in road density could increase transport costs. Calculating the mean effect of road density on transport margins in agriculture at mean corruption level gives a coefficient for $ln(transp)$ of -0.331 with a t-value of -4.786.[13] In other words the effectiveness of roads is strongly conditional on the absence of corruption, at the mean corruption level in the complete sample, the cost reduction from a 1% increase in road density is roughly 0.3%. However the income group dummies remain significant even though their influence is lower if corruption is controlled for.

Medium and low income countries have lower levels of agricultural transport costs, the OECD member status does not influence the results. Time fixed effects have not been significant.[14]

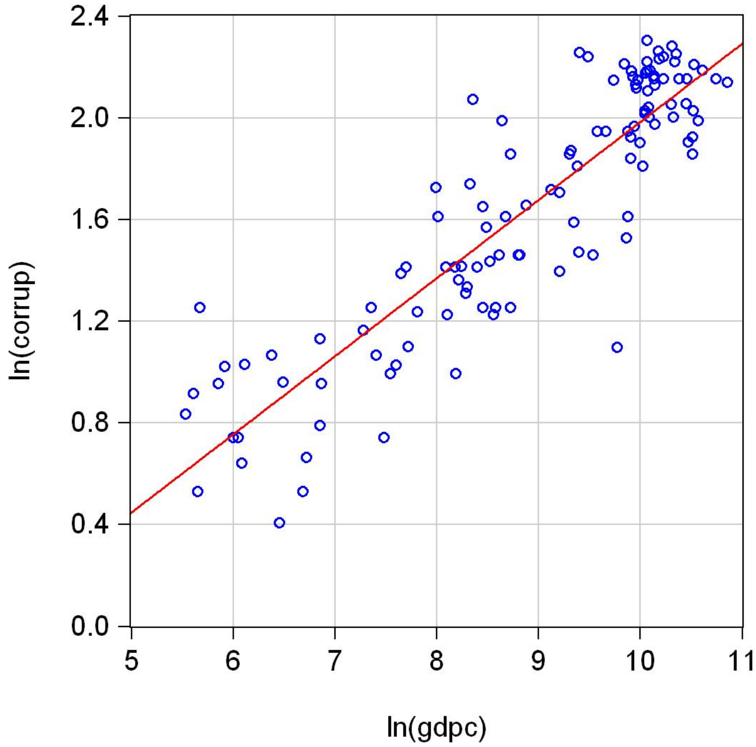
The relation between the transport network density and the transport costs for the complete sample is confirmed not only for the agricultural sectors but also for the weighted transport expenditure of all sectors. These results are shown in table 6. We consistently find negative coefficients for transport as well. However, the influence of transport networks on the weighted transport costs in all sectors is much lower. In addition the explanatory power of the estimations is substantially lower compared to the estimations

[12]Please note the corruption index is defined between 0 and 10 where high levels of the index stand for low levels of corruption.

[13]All mean effects are summarised in table 1 in the appendix.

[14]Not shown here to simplify the exposition.

Figure 1: Correlation between corruption index and GDP per capita (in logs)



for the agricultural sector.

Table 6 here.

Interestingly the non-linearity of transport costs with respect to GDP is significantly confirmed here in contrast to the results for $m_{ag}S$. The GDP has a significant influence on transport costs in four out of the 10 specifications. The influence of GDP is positive and switches to negative if $ln(gdpc)^2$ is included. The influence of $ln(gdpc)^2$ significantly positive if included this is an indication for a diminishing negative influence of the GDP on transport costs. The signs of most other coefficients are in line with the results for agricultural transport costs but the magnitude is lower as well. Time fixes effects have been insignificant here either.

We do observe a significant coefficient for the low income dummy but not for the middle income dummy. Geographical dummies do not have significant influences on transport costs over all sectors.

The results for the inclusion of corruption are not robustly confirmed here. Even though the inclusion of corruption increases the explanatory power, the coefficient of the index as well as the one of the interaction term are highly insignificant and close to zero.

Calculating the effect of transport on the margin at mean corruption gives a coefficient of -0.194 with a t-value of -4.735. This is comparable to the result in equation (9), thus we do not confirm an interaction effect here.

The somehow weaker results for the weighted transport margin in all sectors might partly result from the fact that the production structure differs substantially across countries and thus, as we use sectoral production as weights, the transport cost measure is very heterogeneous compared to agricultural production which is more comparable across countries.

4.2. Country group estimations

The fact that the income groups have been found to be consistently significant as well as some of the geographical dummies even after controlling for a number of country characteristics like climate, population density, urbanisation, land use, education and corruption indicates that there might be a structural difference in the determinants of transport costs between high income countries and developing and transition countries. Hence, we divide our sample into a high income and a medium and low income sample.[15] We run the same regressions as shown above in order to isolate country group specifics. We indeed find substantial differences between the two subsamples.

Table 9 in the appendix shows the results for the margin in agricultural sectors. Estimations (1) - (5) have been done with the high income countries only whereas estimations (6) to (11) only comprise low and medium income countries.[16]

Table 9 here.

It is obvious that the two samples produce quite differing results. For *high income countries* we mostly confirm the results obtained in the complete sample. We find a significantly negative relationship between road infrastructure and transport costs. The estimated coefficients are even higher compared to table 5. Still, the influence of GDP per capita is ambiguous. Densely populated countries have higher transport costs in agriculture as well as highly urbanised countries. Supposedly this is due to the fact that agricultural products have to be carried long ways in these countries. In contrast, higher shares of agriculture in total land use lead to lower transport costs in this sector, which can be attributed to economies of scale.

[15] The descriptive statistics for the two subsamples are shown in the appendix in tables 7 and 8.

[16] Note, to simplify matters not all specifications presented above for the whole sample are replicated here. We only show those with most explanatory power.

We also confirm the positive influence of corruption on transport costs (negative coefficient). However we do not observe an interaction effect, the coefficient of the interaction term is insignificant and its inclusion adds virtually no explanatory power.

The picture is quite different for the middle and low income sample. Here we mostly find positive but sometimes insignificant coefficients for the road density. Hence in middle and low income countries additional roads have no effects on transport costs or even increase these.

We do not find significant effects of GDPC or population density but we confirm the cost increasing influence of urbanisation. The climate indicators especially the temperature index are the only determinants that are significant in most specifications to the contrary of the high income and the complete sample results. For the low and middle income sample we find a strong cost increasing influence of temperatur and a cost-reducing influence of precipitation.

The inclusion of corruption increases the explanatory power. However corruption is only significant if the interaction term is included as well. In this case we find a very high and positive coefficient for roads and high and negative coefficients for corruption and the interaction term. The R^2 is much higher compared to the other specifications, except for equ. (9). Thus for transport costs in the agricultural sector in developing and transition countries we cannot confirm that roads reduce these. However we clearly find that corruption hinders improvements in transaction costs. At the mean level of corruption in this sample, the effect of transport infrastructure on transport margins in agriculture is 0.3341 with a t-value of 2.061. Thus the mean level of corruption in developing countries is so high that additional roads do not only not have a positive impact concerning transport costs in agriculture, they even increase costs in this sector, supposedly due to inefficient allocation of road investments. At very high levels of corruption (index close to 0) additional roads may even increase transport costs overproportionally (coefficient > 1).

What has been found for the margin in agricultural sectors for the two country groups is not true for the weighted margin over all sectors. For both income groups we confirm the negative influence of road infrastructure on tranport costs but with weaker explanatory power and lower coefficients. We consistently confirm the cost-increasing influence of population density ans urbanisation.

Table 10 here.

The countries differ in the influence of climate and in the influence of corruption. We a strong influence of temperature on transport costs in both country groups but with opposing signs. In high income countries higher temperatures reduce the transport margin whereas in middle and low income countries higher temperatures increase the transport margin. This may be explained by differences in technology. For precipitation the influence is low and partly insignificant in industrialised countries but highly negative in developing countries.

We cannot confirm the positive influence of corruption for high income countries, but we find it to be of importance for middle and low income countries, we see a rise in R^2 after inclusion of the corruption index. Still, the corruption index is only significant after controlling for an interaction between corruption and roads. The coefficient for road networks becomes insignificant. Calculating mean effects for table 10 leads to a coefficient of transport at mean corruption of -0.089 in high income countries and -0.380 in middle and low income countries. Hence the inefficiency of road allocation that has been found for the agricultural sector in developing and transition countries does not apply for the margin in all sectors. Still we confirm the interaction effect and find roads impact to be conditional on corruption, only the mean level of corruption is not prohibitive for cost reduction in all sectors but only in agricultural sectors.

Table 1: Effects of ln(transp) on transport margin at mean corruption

Specification	Sample	Coefficient	t-statistic	P-Value
$ln(m_{ag})$	all	-0.331***	-4.786	0.000
$ln(m_{all})$	all	-0.194***	-4.735	0.000
$ln(m_{ag})$	high	-0.527***	-7.516	0.000
$ln(m_{all})$	high	-0.089**	-1.999	0.050
$ln(m_{ag})$	low&med	0.334**	2.061	0.051
$ln(m_{all})$	low&med	-0.380***	-3.516	0.000

5. Conclusion

We have shown by means of pooled OLS estimations in a sample comprising high, medium and low income countries that investments in longer and better roads have the potential to significantly reduce the transport spending. However, this result is of particular importance for agricultural production and transportation of agricultural goods. Even though the negative effect of roads on transport costs is confirmed for all sectors, the importance of the effect is substantially lower on average compared to agricultural transport costs. Other explanatory variables might be more important in industrial sectors.

These results for the complete sample and the confirmation of these for the high income sample show that our proxy for transport costs, the transport margin, is a good and internationally comparable measure of transaction costs from transportation. Our results are in line with most findings for high income countries that use other measures such as the tariff equivalent costs of bad roads.

Splitting the sample into high income countries on the one hand and low and medium income countries on the other hand reveals substantial differences between country groups. In low and medium income countries we find climate and most importantly the level of perceived corruption to be more important in determining transport costs than the availability of infrastructure. We find substantial differences between industrial and developing and transition countries that should be taken into account when infrastructure projects are planned in low and middle income countries.

We find indications for an interaction effect between road status and corruption that could lead to negative effects from roads at very high levels of corruption. The effectiveness of infrastructure programs might thus be conditional on the reduction of corruption in these countries. This is in line with Aschauer [2000] and Hulten [1996] who argue concerning public investment in general that not only the amount of public capital is important but also how efficiently it is invested and used. Especially in the agricultural sector in developing and transition countries this interaction effect is crucial. The mean level of corruption is so high that it is prohibitive for cost reductions in agriculture. Thus, the agricultural sector in these countries does not benefit from higher levels of infrastructure and this is partly due to corruption.

This paper contributes to the literature on infrastructure investment by developing and applying an internationally comparable measure of transport costs which can be calculated for a large and growing number of countries. We isolate important determinants of transport costs and provide an insight on sectoral differences concerning roads' effect on transport costs. Most importantly, we find strong support for the hypothesis that the positive experiences from large infrastructure programs in industrial countries cannot easily applied to developing and transition countries as other important circumstances should be present as well.

We conclude that investment in transport infrastructure can have an high positive effects especially on agricultural production and the efficient marketing of agricultural products. However, this is conditional on low levels of corruption and efficient planning and use of the infrastructure as well as on the climatic circumstances.

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Table 2: Data sources & Description

Variable	Country	Data Source	Description
transport margins (m)	Argentina	IFPRI	Own calculations based on the Social Accounting Matrices or Input-Output tables. Calculation: For each sector we compute: Sectoral spending on transport/Total sectoral production and marketing cost, we then aggregate the margins by calculating an output-weighted average.
	Australia	OECD	
	Austria	Eurostat	
	Bangladesh	IFPRI	
	Belgium	Eurostat	
	Bolivia	IFPRI	
	Brazil	IFPRI	
	Bulgaria	Eurostat	
	Canada	OECD	
	Chile	IFPRI	
	China	OECD	
	Colombia	IFPRI	
	Costa Rica	IFPRI	
	Czech Republic	Eurostat	
	Denmark	Eurostat	
	Egypt	IFPRI	
	El Salvador	IFPRI	
	Estonia	Eurostat	
	Finland	Eurostat	
	France	Eurostat	
	Germany	Eurostat	
	Ghana	IFPRI	
	Great Britain	Eurostat	
	Greece	Eurostat	
	Honduras	IFPRI	
	Hungary	Eurostat	
	India	National statistics	
	Indonesia	IFPRI	
	Ireland	Eurostat	
	Israel	OECD	
	Italy	Eurostat	
	Japan	OECD	
	Kenya	IFPRI	
	Latvia	Eurostat	
	Lithunia	Eurostat	
	Luxemburg	Eurostat	
	Macedonia	Eurostat	
	Malta	Eurostat	
	Mexico	IFPRI	
	Netherlands	Eurostat	
	New Zealand	OECD	
	Nigeria	IFPRI	
	Norway	OECD	
	Paraguay	IFPRI	
	Peru	IFPRI	
	Poland	Eurostat	
	Portugal	Eurostat	
	Romania	Eurostat	
	Russia	National statistics	
	Slovakia	Eurostat	
	Slovenia	Eurostat	
	South Africa	IFPRI	
	Spain	Eurostat	
	Sweden	Eurostat	
	Switzerland	National statistics	
	Tanzania	IFPRI	
	Thailand	IFPRI	
	Turkey	Eurostat	
	Uganda	IFPRI	
	Ukraine	National statistics	
	Uruguay	IFPRI	
	USA	OECD	
	Vietnam	IFPRI	
	Zambia	IFPRI	

road density (transp)	all	World development indicators	The road density has been calculated based on the indicators: "roads, total network"," roads, paved percent" and "surface, total". It is defined as paved roads/km^2 surface
GDP per capita (gdpc)	all	World development indicators	GDP per capita in constant US$
population density (popdens)	all	World development indicators	
Temperature index (temp)	all	World metereological organization	The index has been calculated as yearly maximum squared + yearly minimum squared
Precipitation (precip)	all	World metereological organization	Precipitation per year in mm
urbanisation (urban)	all	World development indicators	urban population as % of total
agricultural land(agrland)	all	World development indicators	Agricultural land as % of land area
Corruption	all	Transparency international	The perceived corruption index is defined between 0 and 10 where 10 means “no corruption”
Education (edu)	all	World development indicators	% of labor force with tertiary education
Motor vehicles (vehicl)	all	World development indicators	Motor vehicles per 1000 persons

Table 3: Descriptive statistics - Dependent variables and control variables

Variable	transport margins		paved roads/ surface	gdp/ capita US$	population density	urban population as % of total	Temperature index	precipitation in mm	Agricultural land as % of total	Motor vehicles per 1000 persons	% of labor force with tertiary education	Corruption index
Abbrev.	m_{ag}	m_{all}	transport	gdpc	popdens	urban	temp	precip	agrland	vehicl	edu	corrup
Mean	0.035	0.060	0.788	13264.90	167.99	65.67	7376.63	937.49	44.57	384.65	24.86	5.80
Median	0.026	0.058	0.371	8197.10	95.18	67.40	401.18	746.175	49.57	442.00	23.80	5.70
Std. dev.	0.027	0.026	0.966	12440.90	378.32	18.63	51972.86	530.80	20.52	210.98	12.87	2.50
Min	0.004	0.011	0.003	253.48	2.43	12.02	6.85	54.74	3.298	8.00	3.00	1.50
Max	0.149	0.147	6.086	51934.26	3112.25	97.26	417559.03	2922.00	84.88	738.00	83.200	10.00
# obs	135	135	135	135	135	135	115	114	133	58	107	120

Table 4: Descriptive statistics - Dummy variables

	Regional Dummies							Income dummies			Year dummies		
	Eastern Europe / Central Asia	Middle East / North Africa	Sub Sahara Africa	Latin America	High Income	East Asia / Pacific	South Asia	High	Middle	Low	1995	2000	2005
Mean	0.141	0.007	0.074	0.111	0.578	0.037	0.052	0.578	0.348	0.074	0.336	0.343	0.321
Median	0.000	0.000	0	0	1	0	0	1	0	0	0	0	0
Std. dev.	0.350	0.086	0.251	0.316	0.495	0.190	0.223	0.495	0.479	0.251	0.474	0.477	0.469
Min	0	0	0	0	0	0	0	0	0	0	0	0	0
Max	1	1	1	1	1	1	1	1	1	1	1	1	1
# obs	19	1	10	15	78	5	7	78	47	10	45	46	44
# countries	9	1	7	12	29	3	3	29	27	8			

Table 5: Results from pooled OLS regression for margin in agricultural sectors, whole sample

Spec. No.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
dependent	$ln(m_{ag})$	$ln(m_{ag})$	$ln(m_{ag})$	$ln(m_{ag})$	$ln(m_{ag})$	$ln(m_{ag})$	$ln(m_{ag})$	$ln(m_{ag})$	$ln(m_{ag})$	$ln(m_{ag})$
# of obs	135	135	135	135	114	113	114	114	105	105
ln(transp)	-0.077**	-0.087*	-0.074	-0.061	-0.152*	-0.102	-0.292***	-0.297***	-0.336***	0.167
	(-2.003)	(-1.738)	(-0.718)	(-0.633)	(-1.727)	(-1.083)	(-3.757)	(-3.317)	(-4.386)	(0.841)
ln(gdpc)		0.02	0.01	-0.175	-0.16	-0.219*	-0.126	-0.107	-0.061	-0.009
		(0.301)	(0.109)	(-1.611)	(-1.459)	(-1.887)	(-0.947)	(-0.878)	(-0.299)	(-0.045)
ln(popdens)			-0.02	0.002	0.083	0.085	0.129*	0.112	0.145**	0.206***
			(-0.172)	(0.02)	(0.877)	(0.925)	(1.806)	(1.434)	(2.116)	(3.494)
ln(urban)				0.901***	1.031***	1.129***	0.118	1.797***	0.137	0.331
				(3.247)	(2.785)	(3.047)	(0.28)	(3.648)	(0.295)	(0.719)
ln(temp)					-0.005	0.033	0.028	0.061*	0.038	0.005
					(0.073)	(0.701)	(0.817)	(1.69)	(0.975)	(0.124)
ln(precip)					0.091	0.139	0.015	0.22*	-0.004	0.08*
					(1.278)	(1.366)	(0.155)	(1.678)	(-0.031)	(1.587)
ln(agrland)						-0.17				
						(-1.462)				
ln(corrup)									-0.224	-0.712**
									(-0.68)	(-2.011)
ln(corrup)*ln(transp)										-0.304***
										(-3.041)
low income							-2.742***		-2.886***	-1.654**
							(-5.222)		(-4.985)	(-2.145)
middle income							-0.359		-0.437	-0.269
							(-1.539)		(-1.154)	(-0.901)
East Asia/Pacific								0.094		
								(0.019)		
Europe/Centr. Asia								-0.095		
								(-0.405)		
Latin America								-0.959***		
								(-2.56)		
South Asia								1.352***		
								(2.608)		
Sub Sah. Africa								-0.005		
								(-0.006)		
constant	-3.749***	-3.935***	-3.751***	-5.921***	-7.909***	-7.29***	-3.854***	-12.716***	-4.154***	-0.526***
	(-45.391)	(-6.404)	(-2.748)	(-4.086)	(-5.037)	(-4.753)	(-2.782)	(-5.798)	(-2.492)	(-3.068)
R^2	0.029	0.03	0.031	0.108	0.174	0.194	0.344	0.321	0.398	0.408
adj. R^2	0.022	0.015	0.009	0.081	0.128	0.140	0.294	0.248	0.335	0.345

t-statistics in parantheses, ***, **, * indicate significance on 1%, 5% and 10% level respectively

Table 6: Results from pooled OLS regression for margin in all sectors, whole sample

Spec. No.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
dependent	$ln(m_{all})$	$ln(m_{all})$	$ln(m_{all})$	$ln(m_{all})$	$ln(m_{all})$	$ln(m_{all})$	$ln(m_{all})$	$ln(m_{all})$	$ln(m_{all})$	$ln(m_{all})$
# of obs	135	135	135	135	114	114	106	106	105	105
ln(transp)	-0.007	-0.045	-0.026	-0.026	-0.141***	-0.195***	-0.167***	-0.168***	-0.194***	-0.183
	(-0.284)	(-1.392)	(-0.414)	(-0.408)	(-3.041)	(-4.36)	(-3.71)	(-3.358)	(-4.812)	(-1.304)
ln(gdpc)		0.076*	0.063	0.06	0.17**	0.134*	-0.95*	0.155	-1.37**	-1.382**
		(1.932)	(1.038)	(0.843)	(2.311)	(1.688)	(-1.723)	(1.82)	(-2.336)	(-2.441)
ln(popdens)			-0.029	-0.029	0.096**	0.108***	0.086**	0.095**	0.133***	0.135***
			(-0.404)	(-0.397)	(2.131)	(3.13)	(2.351)	(2.567)	(4.254)	(4.472)
ln(urban)				0.014	-0.105	-0.394	-0.129	0.049	0.012	0.019
				(0.09)	(-0.518)	(-1.476)	(-0.508)	(0.206)	(0.062)	(0.094)
ln(temp)					-0.01	0.003	0.002	-0.004	0.035	0.034
					(-0.386)	(0.093)	(0.058)	(-0.143)	(1.3)	(1.193)
ln(precip)					-0.123	-0.156**	-0.192***	-0.178*	-0.186**	-0.185**
					(-0.463)	(-2.009)	(-2.802)	(-1.704)	(-2.6)	(-2.367)
$ln(gdpc)^2$							0.061**		0.085**	0.086***
							(2.001)		(2.584)	(2.694)
ln(corrup)									-0.089	-0.101
									(-0.588)	(-0.504)
ln(corrup)*ln(transp)										-0.007
										(-0.095)
low income						-1.15***	-1.182**		-1.382***	-1.357**
						(-2.926)	(-2.62)		(-2.945)	(-2.258)
middle income						-0.271	-0.177		-0.358	-0.354
						(-1.387)	(-1.014)		(-1.621)	(-1.505)
East Asia/Pacific								0.239		
								(0.933)		
Europe/Centr. Asia								-0.241		
								(-0.991)		
Latin America								-0.186		
								(-0.867)		
South Asia								0.307		
								(0.991)		
Sub Sah. Africa								-0.245		
								(-0.927)		
constant	-2.916***	-3.632***	-3.364***	-3.398***	-3.592***	-1.908*	2.006	-3.762***	3.025	3.05
	(-56.643)	(-9.601)	(-3.874)	(-3.657)	(-4.041)	(-1.77)	(0.801)	(-3.427)	(1.155)	(1.184)
R^2	0.001	0.035	0.038	0.038	0.122	0.195	0.228	0.19	0.267	0.267
adj. R^2	-0.007	0.021	0.016	0.009	0.072	0.134	0.155	0.103	0.189	0.18

t-statistics in parantheses, ***, **, * indicate significance on 1%, 5% and 10% level respectively

Table 7: Descriptive statistics high income sample

Variable	transport margins		paved roads/ surface	gdp/ capita US$	population density	urban population as % of total	Temperature index	precipitation in mm	Agricultural land as % of total	Motor vehicles per 1000 persons	% of labor force with tertiary education	Corruption index
Abbrev.	m_{ag}	m_{all}	transport	gdpc	popdens	urban	temp	precip	agrland	vehicl	edu	corrup
Mean	0.0314	0.0639	1.213	21120.54	217.34	73.61	340.12	876.16	42.40	524.77	26.86	7.27
Median	0.0241	0.0626	0.926	21330.45	109.58	73.90	295.30	747.00	49.18	521.00	26.50	7.55
Std. dev.	0.0247	0.0240	1.063	10737.43	479.02	11.88	218.30	419.41	21.04	110.15	12.49	1.80
Min	0.0035	0.0108	0.032	2858.17	2.43	49.50	6.85	383.92	3.40	256.00	8.60	2.99
Max	0.1289	0.1234	6.086	51934.26	3112.25	97.26	1068.50	2375.82	71.83	738.00	83.20	10.00
# obs	78	78	78	78	78	78	75	75	76	35	75	74

Table 8: Descriptive statistics low & middle income sample

Variable	transport margins		paved roads/ surface	gdp/ capita US$	population density	urban population as % of total	Temperature index	precipitation in mm	Agricultural land as % of total	Motor vehicles per 1000 persons	% of labor force with tertiary education	Corruption index
Abbrev.	m_{ag}	m_{all}	transport	gdpc	popdens	urban	temp	precip	agrland	vehicl	edu	corrup
Mean	0.0388	0.0561	0.1917	2288.48	97.79	54.26	20570.07	1055.42	47.28	171.41	20.19	3.37
Median	0.0378	0.0534	0.1067	1775.14	71.53	58.40	819.36	745.35	50.46	149.84	19.00	3.15
Std. dev.	0.0294	0.0281	0.2411	1858.78	128.09	20.67	87303.57	688.18	19.50	133.42	12.69	1.33
Min	0.0052	0.0120	0.0026	253.48	6.81	12.02	95.50	54.74	3.30	8.00	3.00	1.50
Max	0.1494	0.1472	1.0765	7197.17	872.09	90.50	417559.03	2922.00	84.88	467.00	66.10	7.94
# obs	57	57	57	57	57	57	40	39	57	23	32	46

Table 9: Results from pooled OLS regression for margin in agricultural sectors, subsamples

Spec. No.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
dependent	$ln(m_{ag})$	$ln(m_{ag})$	$ln(m_{ag})$	$ln(m_{ag})$	$ln(m_{ag})$	$ln(m_{ag})$	$ln(m_{ag})$	$ln(m_{ag})$	$ln(m_{ag})$	$ln(m_{ag})$	$ln(m_{ag})$
Sample	high	high	high	high	high	low&med.	low&med.	low&med.	low&med.	low&med.	low&med.
# of obs	78	73	73	69	69	57	35	36	37	32	32
ln(transp)	-0.227*	-0.463***	-0.38***	-0.56***	0.439	-0.013	0.271	0.302*	0.203	0.228*	1.578**
	(-1.689)	(-7.831)	(-5.724)	(-9.046)	(0.415)	(-0.142)	(2.111)	(1.898)	(1.465)	(1.898)	(2.256)
ln(gdpc)	-0.383*	-0.074	-0.199	0.313	0.282	0.092	-0.095	-0.413	-0.097	-0.482	-0.334
	(-1.99)	(-0.493)	(-1.366)	(1.569)	(1.508)	(0.477)	(-0.219)	(-0.816)	(-0.276)	(-1.031)	(-0.674)
ln(popdens)	0.031	0.193***	0.169***	0.207***	0.265***	0.112	0.001	-0.241	-0.199	-0.035	-0.318
	(0.277)	(4.046)	(4.101)	(4.099)	(3.06)	(0.781)	(0.053)	(-0.693)	(-0.7)	(-0.132)	(-0.872)
ln(urban)	0.863*	0.831	1.123*	1.407**	1.329**	0.571	1.055	1.406	2.476***	1.586	0.815
	(1.699)	(1.559)	(1.932)	(2.326)	(2.191)	(1.322)	(1.091)	(1.302)	(3.037)	(1.567)	(0.694)
ln(temp)		0.105*	0.208**	0.071	0.071		0.874***	0.969***	0.827***	0.97***	0.817***
		(1.925)	(2.097)	(1.344)	(1.29)		(3.665)	(4.39)	(4.108)	(3.981)	(3.981)
ln(precip)		0.078	0.116	0.223	0.201		-0.145	-0.552**	-0.328	-0.461	-0.537**
		(0.335)	(0.494)	(0.927)	(0.861)		(-0.464)	(-2.445)	(-1.298)	(-1.344)	(-2.048)
ln(agrland)			-0.245*					0.419			
			(-1.695)					(0.851)			
ln(corrup)				-1.452***	-1.382***					0.585	-2.478
				(-3.883)	(-3.971)					(0.766)	(-1.571)
ln(corrup)*ln(transp)					-0.496						-1.084**
					(-0.943)						(-2.005)
East Asia/Pacific									0.794*		
									(1.928)		
Latin America									-0.321		
									(-0.533)		
South Asia									1.954***		
									(4.536)		
Sub Sah. Africa									1.294***		
									(3.083)		
C	-3.903*	-8.592***	-8.451***	-12.898***	-12.536***	-6.925***	-10.907***	-8.14***	-14.72***	-9.116***	-0.662
	(-1.811)	(-3.738)	(-3.485)	(-4.708)	(-4.735)	(-4.2)	(-4.44)	(-3.238)	(-5.495)	(-3.433)	(-0.131)
R^2	0.211	0.372	0.404	0.493	0.503	0.145	0.442	0.293	0.651	0.407	0.435
adj.R^2	0.168	0.315	0.339	0.435	0.437	0.079	0.323	0.069	0.517	0.234	0.197

t-statistics in parenthesis, ***, **, * indicate significance on 1%, 5% and 10% level respectively

Table 10: Results from pooled OLS regression for margin in all sectors, subsamples

Spec. No.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
dependent	$ln(m_{all})$	$ln(m_{all})$	$ln(m_{all})$	$ln(m_{all})$	$ln(m_{all})$	$ln(m_{all})$	$ln(m_{all})$	$ln(m_{all})$	$ln(m_{all})$
Sample	high	high	high	high	low&med.	low&med.	low&med.	low&med.	low&med.
# of obs	78	73	71	71	57	39	39	34	34
ln(transp)	-0.033	-0.137***	-0.109***	0.483	-0.051	-0.414***	-0.375**	-0.434***	0.269
	(-0.333)	(-2.956)	(-2.685)	(1.07)	(-0.648)	(-4.126)	(-2.671)	(-5.349)	(0.729)
ln(gdpc)	-0.09	0.1	0.121	0.102	0	0.098	0.096	0.356*	0.439**
	(-0.751)	(1.273)	(1.525)	(1.378)	(0.001)	(0.504)	(0.356)	(1.737)	(2.212)
ln(popdens)	-0.042	0.078***	0.093***	0.128***	-0.026	0.932***	1.151***	0.996***	0.849***
	(-0.517)	(2.736)	(3.156)	(2.973)	(-0.202)	(4.468)	(4.814)	(4.861)	(3.349)
ln(urban)	0.207	0.18	0.399**	0.353**	0.048	0.73*	1.044*	0.63	0.219
	(0.582)	(0.609)	(2.247)	(2.086)	(0.277)	(1.824)	(1.985)	(1.565)	(0.487)
ln(temp)		-0.101***	-0.079***	-0.079***		0.081**	0.049	0.159**	0.073
		(-3.718)	(-3.109)	(-3.169)		(2.155)	(1.136)	(2.313)	(0.923)
ln(precip)		-0.082	-0.187*	-0.2**		-0.494***	-0.793***	-0.521***	-0.554***
		(-0.766)	(-1.964)	(-2.131)		(-3.468)	(-4.122)	(-2.902)	(-3.423)
ln(corrup)			-0.013	0.028				-0.775	-2.382**
			(-0.06)	(0.132)				(-1.457)	(-2.685)
ln(corrup)*ln(transp)				-0.294					-0.566*
				(-1.305)					(1.95)
Europe/Centr. Asia							-0.943**		
							(-2.579)		
Latin America							-0.279		
							(-0.668)		
South Asia							-0.697		
							(-1.626)		
Sub Sah. Africa							-0.26		
							(-0.782)		
constant	-2.661*	-3.824***	-4.399***	-4.184***	-3.218**	-8.532***	-7.761***	-9.828***	-5.412
	(-1.729)	(-3.515)	(-3.445)	(-3.364)	(-2.465)	(-5.151)	(-2.987)	(-5.739)	(1.666)
R^2	0.053	0.235	0.319	0.335	0.035	0.363	0.452	0.474	0.541
adj. R^2	0.001	0.165	0.241	0.246	-0.04	0.244	0.256	0.332	0.395

t-statistics in parantheses, ***, **, * indicate significance on 1%, 5% and 10% level respectively

Table 11: Results from pooled OLS regression for different specifications

Spec. No.	(a1)	(a2)	(a3)	(a4)	(a5)	(a6)	(a7)	(a8)	(a9)
dependent	$ln(m_{ag})$	$ln(m_{ag})$	$ln(m_{all})$	$ln(m_{all})$	$ln(m_{ag})$	$ln(m_{ag})$	$ln(m_{all})$	$ln(m_{ag})$	$ln(m_{all})$
sample	complete	complete	complete	complete	high	high	high	low&med.	low&med.
# of obs	45	114	49	89	73	31	35	28	33
ln(transp)	-0.493***	-0.287***	-0.222***	-0.184***	-0.447***	-0.564***	-0.088	0.067	-0.254
	(-4.482)	(-4.128)	(-3.455)	(-4.161)	(-5.133)	(-5.706)	(-0.534)	(0.214)	(-1.298)
ln(gdpc)	-0.034	-1.344	0.406**	0.235***	-4.423	0.312	0.179	-1.94	0.598
	(-0.111)	(-1.586)	(2.483)	(2.778)	(-1.335)	(0.986)	(0.776)	(-0.578)	(0.371)
ln(popdens)	0.242***	0.127*	0.137***	0.113***	0.176**	0.275***	-0.031	-0.197	0.538
	(4.015)	(1.797)	(2.75)	(3.146)	(2.421)	(3.996)	(-0.222)	(-0.332)	(1.39)
ln(urban)	-0.237	0.329	-0.484	-0.2	0.79	1.358	-0.014	-0.365	0.300
	(-0.219)	(0.856)	(-0.951)	(-0.532)	(1.62)	(1.637)	(-0.025)	(-0.38)	(0.652)
ln(temp)	0.134	0.039	-0.015	-0.079**	0.15*	0.037		0.517	0.077**
	(1.036)	(0.759)	(-0.368)	(-2.415)	(1.804)	(0.536)		(1.224)	(2.173)
ln(precip)	0.009	-0.008	0.004	-0.201**	0.042	0.032		-0.217	-0.387**
	(0.024)	(0.068)	(0.029)	(-2.111)	(0.203)	(0.119)		(-0.506)	(-2.264)
ln(edu)	0.058			-0.096					
	(0.178)			(-0.79)					
ln(vehicl)	0.794**		-0.306*			1.641***	-0.754		
	(2.62)		(-1.945)			(3.772)	(-1.652)		
ln(corrup)						-2.449***			
						(-3.528)			
$\ln(gdpc)^2$		0.068			0.231			0.133	-0.031
		(1.454)			(1.314)			(0.581)	(-0.291)
low income		-3.071***	-0.999**						
		(-5.128)	(-2.104)						
middle income		-0.377	-0.199						
		(1.541)	(-0.548)						
constant	-9.494**	0.712	-3.37**	-2.701*	11.971	-19.746***	0.288	4.287	-7.493
	(-2.222)	(0.203)	(-2.609)	(-1.983)	(0.756)	(-4.766)	(0.083)	(0.321)	(-1.203)
R^2	0.427	0.357	0.377	0.25	0.389	0.736	0.177	0.443	0.257
adj. R^2	0.257	0.301	0.233	0.185	0.323	0.641	0.036	0.209	0.049

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