The cost of road infrastructure in developing countries

Paul COLLIER[a]

Martina KIRCHBERGER[a*]

Måns SÖDERBOM[b]

[a] *Centre for the Study of African Economies,*
Department of Economics, University of Oxford

[b] *Department of Economics, University of Gothenburg*

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Abstract:
A growing literature shows that there are significant and positive benefits of transport infrastructure for development. However, research on the cost side lags behind so that little is known about differences in the cost of infrastructure countries face. To our knowledge, this is the first paper that examines drivers of unit costs of construction of transport infrastructure with a large dataset of 3,322 unit costs of road work activities in low and middle income countries. We find that: (i) there is a large dispersion in unit costs for comparable road work activities; (ii) after accounting for environmental drivers of costs such as terrain ruggedness and proximity to markets, residual unit costs are significantly higher in conflict countries; (iii) there is evidence that costs are higher in countries with higher levels of corruption; (iv) these effects are robust to controlling for a country's public investment capacity and business environment; (v) higher unit costs are significantly negatively correlated with infrastructure provision.

Keywords: construction, infrastructure, transport.

JEL classification: O1, L7, H5, R4.

*Correspondence: Centre for the Study of African Economies (CSAE), Department of Economics, Manor Road Building, Oxford OX1 3UQ, UK; Email: martina.kirchberger@economics.ox.ac.uk.

1 Introduction

This paper analyzes a new and highly detailed global dataset on the unit costs of road construction and maintenance. Roads are archetypal of public economic infrastructure. While telecoms, power and railways are often privately financed, the practical scope for private financing of roads in developing countries has proved to be extremely limited. Yet over recent decades donors have shifted their support from such infrastructure, which was the initial rationale for aid, to social priorities, as exemplified by the Millennium Development Goals. In low-income counties this may have contributed to the deterioration in provision: for example, there is evidence that since the 1980s the African road stock has actually contracted (Teravaninthorn and Raballand 2009).

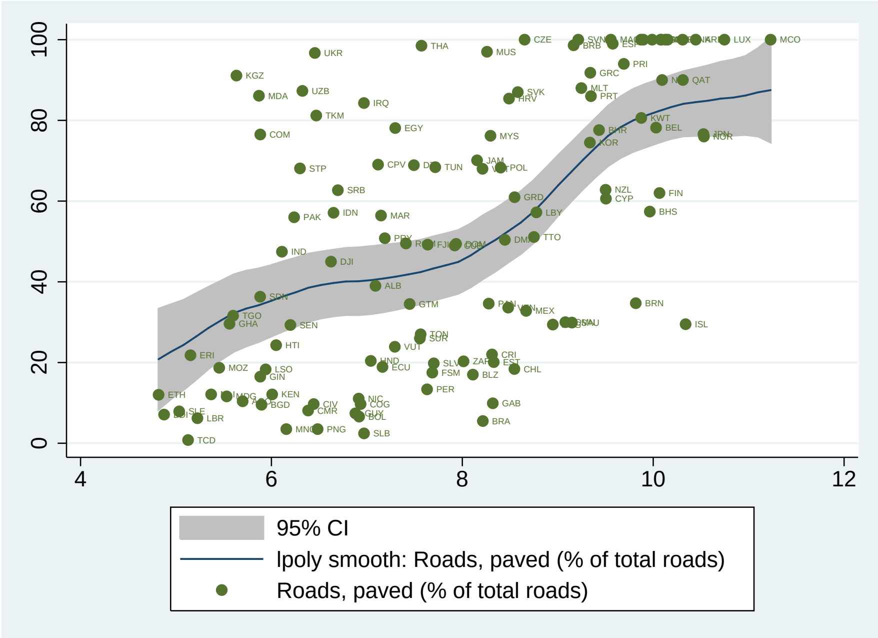
Unsurprisingly, the road stock is associated with the level of income. One practical measure is the proportion of the stock which is paved. As shown in Figure 1, by the time a country has reached OECD levels of development (a GDP per capita of about US$26,000) around 80 percent of roads are paved, whereas in a country with a per capita income level of US$2,70 such as Togo, only around 30 percent are paved.

If roads complement private investment, it is reasonable to think of the massive public investment implied by such a transformation as not merely a consequence of development, but as integral to it. Yet as indicated by Figure 1, the pace at which roads are paved appears to lag rather than lead general development. Between a GDP per capita of US$90 to US$3,000 investment in paving roads looks to stall before accelerating as countries approach the OECD level of income. Costs are important because they can lead to an income and a substitution effect. First, countries can afford fewer roads when the cost per km is high; second, investments projects failing to produce a high enough net present value or internal rate of return, will be likely to lose out to other projects.

The contribution of this paper is threefold. First, we introduce a new data set of 3,322 unit costs of road work activities across 99 countries. To our knowledge this is the first paper that provides clear quantitative evidence on the unit cost of building public road infrastructure across a large set of countries in the context of development. To make meaningful comparisons of unit costs of construction data, requirements are fairly stringent. At a minimum, one needs detailed information on the year and location of the work activity, type of costs (estimated, actual or contracted) and the specificities of the construction or maintenance activity (what type of road work activity it is). All these variables are present in our data set. Second, we examine whether there is residual variation in unit costs once we control for obvious cost drivers such as terrain ruggedness and access to markets. We focus on two dimensions of the environment a firm operates: conflict and corruption. Finally, based on these findings, we propose a research agenda.

Our analysis yields five main findings. First, we show that there is a large dispersion in unit costs across countries for comparable road work activities. For example, the difference between countries of an asphalt overlay of 40 to 59 mm amounts to a factor of three to four. Second, we find that after accounting for environmental drivers of costs such as terrain ruggedness and proximity

Figure 1: Correlation between % of Paved Roads and Log of GDP per Capita in 2000



Notes: World Development Indicators 2012.

to markets, residual unit costs are significantly higher in conflict countries. Countries which are in conflict have about 30% higher unit costs. This result is robust to different measures of conflict and political instability. Third, we also find evidence that costs are higher in countries with higher levels of corruption. Moving a country from the 75th percentile of corruption to the 25th percentile of corruption is associated with 6.3% lower unit costs. Countries with corruption levels as measured by the Worldwide Governance Indicators above the median in the sample have about 12% higher costs. Fourth, these effects are robust to controlling for a country's public investment capacity and business environment. Finally, we find that higher unit costs are significantly associated with lower levels of infrastructure provision.

This paper is at the intersection of several strands of the literature. First, there is a growing literature on the effect of transport infrastructure on transport costs, trade volume, market development, productivity, and poverty and consumption. Limao and Venables (2001) find that the cost of shipping a 40-foot container from Baltimore to various locations is higher the poorer the infrastructure of the destination and transit country. Estimating a gravity model including an infrastructure variable, they find that poor infrastructure significantly reduces trade flows. Further, they find that doubling transport costs from the median reduces trade volume by 45 percent. Donaldson (2012) using micro data from colonial India finds that railroads decreased transport costs, increased trade, and raised real income levels. Mu and van de Walle (2011) show that rural roads in Vietnam have a significant effect on market development, and this effect is stronger for initially less developed markets. Shiferaw et al. (2011) evaluate the effect of two Road Sector Development Programs during 1997-2009 in Ethiopia and find that improved road accessibility increases value added per worker. Dercon et al. (2009) show that access to an all-weather road in rural Ethiopia reduced poverty by 6.9 percentage points and increased consumption by 16.3 percentage points. Khandker et al. (2009) find that Bangladesh's Rural Development Project and the Rural Roads and Markets Improvement and Maintenance Project led to poverty reductions of 3-4% and 5-6%, respectively. Jacoby and Minten (2009) find that an elimination of transport costs would substantially lower poverty in their study region in Madagascar. Stifel et al. (2012) apply Jacoby and Minten's methodology to a region in Ethiopia and arrive at a similar conclusion.

Second, while substantial progress is being made on evaluating the benefits of infrastructure, research on the cost side is lagging behind. The paper relates to the recent effort in collecting data on unit costs of different types of infrastructure investments across countries. It is is complementary to the following studies: AFRICON (2008) analyze 115 road contracts in Sub-Saharan Africa and find significant economies of scale for projects covering a length longer than 50 km. Given the relatively small number of contracts, they have to aggregate various work activities into fairly coarse groups to create comparisons. In addition to coverage of contracts of all regions worldwide, the advantage of our paper is that we can control for systematic differences in the cost of construction by including fixed effects at the very detailed work activity level. Two studies by Alexeeva et al. (2008) and Alexeeva et al. (2011) examine evidence for corruption in the roads sector, using data on 109 road work contracts and 76 supervision consultancy contracts in 13 Sub-Saharan African countries, and a sample of 200 completed and ongoing road contracts in 14 European and Central Asian countries, respectively. This paper differs from these two studies in that we focus on differences across countries, rather than the link between the bidding process, input costs and the unit cost of particular road work contracts[1]. Buys et al. (2010) use a subset of 465 roads contracts in Sub-Saharan African countries from the ROCKS database to argue that upgrading of the roads network could lead to an expansion of trade by US$250 billion over 15 years, at a cost of US$20 billion for upgrading and US$1 billion annually for maintenance costs.

Third, the paper relates to a fairly recent literature on government procurement processes and waste associated with it. Bandiera et al. (2009) test for active (for example, corruption) and passive waste (for example, the inability of the civil servant to select the cheapest product) in the procurement of 21 generic goods by Italian public bodies and find substantial heterogeneity in prices paid by different types of bodies, with the average ministry paying about 40% higher prices compared to semi-autonomous bodies; passive waste is found to account for about 83% of waste. Di Tella and Schargrodsky (2003) find that a crack-down on corruption led to a 10-15% decline in prices paid by hospitals in Buenos Aires for basic supplies compared to the pre-crack-down period. Several studies investigate the bidding behavior of firms and efficiency of auctions in public procurement. Hyytinen et al. (2007) study the procurement of cleaning contracts in municipalities in Sweden and find that in 58% of the time, the lowest bidder does not win the auction and then contrast the behaviors of left-wing and right-wing governments. Huysentruyt (2011) examines 457 completed DFID contracts and compares for-profit and non-profit firms' bidding and contract implementation characteristics. She finds that contract renegotiations take place in 60% of all contracts, with the cost of renegotiations being about 30-50% higher when contracting with for-profit organization compared

[1] Ideally we would have liked to test their hypotheses on the larger data set we employ in our study; unfortunately, detailed bidding information was only collected for a small number of contracts in the database.

to non-profit organizations. Increasing attention has also been attributed to infrastructure auctions in developing countries. Estache and Iimi (2009) find joint bidding to be pro-competitive, especially when involving local entreprises from analysing 86 road work contracts. Estache and Iimi (2010) use data from 45 auctions in the roads sector of projects by the World Bank and the former Japan Bank for International Cooperation and find that in the roads sector bids submitted by entrant bidders are substantially more aggressive.

Finally, we aim to contribute to the literature on conflict and corruption. To our knowledge, the only study quantitatively investigating the link between conflict and the cost of transport infrastructure is Benamghar and Iimi (2011) who use data on 157 rural road projects in Nepal and show that the number of security incidents is significantly and and positively correlated with the value of submitted bids, cost overruns, and project delays. Considering corruption in transport infrastructure, Olken (2007) finds that missing expenditures amounted to on average 24% of the total cost of the road in his experiment in Indonesia. See Blattman and Miguel (2010) for a recent review on the literature on conflict and Olken and Pande (2012), Zitzewitz (2012) and Banerjee et al. (2012) on corruption in developing countries.

The paper is organized as follows. Section 2 sets the scene for our focus on conflict and corruption. Section 3 presents a theoretical framework for analyzing the drivers of unit costs of road construction and maintenance. Section 4 describes our data. Section 5 outlines the econometric specification; section 6 discusses the results and sketches avenues for further research; the final section concludes.

2 Conflict and Corruption in the Roads Sector

The focus of our analysis is on the link between conflict and corruption and unit costs of road work activities. The focus on conflict is motivated by the fact that 1.5 billion people live in conflict-affected or fragile states, and these states lag behind on measures like poverty reduction and other developmental outcomes (World Bank 2011b). If these finance constrained states face high road construction costs, and roads construction and a better network reduce conflict by raising the opportunity cost of joining rebel groups through employment, as well as improved economic outcomes through better connectivity, then they might be trapped in an equilibrium with high costs of transport infrastructure and instability. Further, public work contracts, including roads, are subject to substantial levels of corruption. According to Transparency International's Bribe Payers Survey of over 3,000 business executives worldwide, public works contracts and construction is the sector with the highest propensity of paying bribes to officials and other firms (Transparency International 2011). As this paper attempts to establish a first set of facts on differences in costs, a focus on the link between corruption and costs is a natural priority.

A review by the World Bank's Transport Research Support Program on the roads sector in conflict countries states that *"...projects that take place in conflict settings would almost always be more costly than in other settings because of challenges such as insecurity and low government capacity"*

(Rebosio and Wam 2011). Higher costs can be due to the costs of monitoring of the security situation of an area, potentially undergoing substantial risks to visit the construction site, and the associated limited planning possible. In addition to protection of the staff working on the particular roads project, firms also risk that supplies are cut off due to disruptions of transport networks. If conflict takes place along ethnic lines, road construction firms might need to ensure to employ an ethnically balanced workforce, in order not to further fuel the conflict or becoming targets of violence themselves. Consultations with communities, while helpful, are also significantly adding to the cost of construction. Not only the construction but also the procurement process can be riskier in conflict countries. Rebosio and Wam (2011) and Benamghar and Iimi (2011) give evidence for these effects on risks and costs from Nepal: a government employed road engineer was killed in the Terai regions; road construction teams were constantly monitoring the security situation and adjusting their operations accordingly; in certain regions violence and intimidation were employed during the bidding process to prevent firms from submitting a bid for profitable project.

Allegations of fraud, corruption or collusion were made in about one fourth of the 500 approved World Bank financed projects with a road component between 2000-2010 (World Bank 2011a). Roads contracts procured through the World Bank are usually awarded in a one stage sealed bid auction, with the lowest bidder winning the auction. Alexeeva et al. (2011) find that in about 20% of the auctions in their sample of 200 contracts in Europe and Central Asia, at least 50% of firms who acquired bidding documents do not bid, the winning bid is not selected for detailed examination, or there is a time overrun of more than 30% of the contracted period. The estimates of costs of collusion and cartels in the road sector are large and range between 8% and 60% (World Bank 2011a). Considering that substantial resources are allocated to road construction and maintenance (US$56 billion between 2000-2010 by the World Bank alone), this represents a massive waste of funds. Further evidence from investigations discussed in (World Bank 2011a) is striking: in Bangladesh, companies paid officials up to 15% of the contract value in exchange for award of the contract. In an African country, fraudulent claims such as cement contents and thinner layers than specified accounted for 15-20% of the bid price; the use of substandard materials imposes costs ex-post through higher maintenance costs and costs on vehicle drivers due to worse road conditions and might eventually lead to even negative rates of return of a particular project (Kenny 2009).

3 Theoretical Framework

This section develops a simple theoretical framework with the purpose of guiding the empirical analysis. Consider a particular type of road work activity, for example, a construction of a new 2 lane highway. Denote the length of the highway as q. Firms employ labor x_1 and capital x_2 in the production of highways and minimize a cost function

$$\min_{x_1,x_2} w_1x_1 + w_2x_2 \text{ subject to } q = f(x_1, x_2) \tag{1}$$

where w_1 is the price of labor and w_2 is the price of capital. Firms are assumed to be price takers in input markets. Further, assume that the firm has a Cobb-Douglas production function so that

$f(x_1,x_2)=A^{-\delta}x_1^{\alpha}x_2^{\beta}$, where $A^{-\delta}$ is an inefficiency parameter, $0<\alpha<1$, and $0<\beta<1$[2].

The conditional factor demands from the firm's minimization problem for x_1 and x_2 are

$$x_1(w_1,w_2,q)=A^{\frac{\delta}{\alpha+\beta}}\left(\frac{w_2}{w_1}\frac{\alpha}{\beta}\right)^{\frac{\beta}{\alpha+\beta}}q^{\frac{1}{\alpha+\beta}} \tag{2}$$

$$x_2(w_1,w_2,q)=A^{\frac{\delta}{\alpha+\beta}}\left(\frac{w_1}{w_2}\frac{\beta}{\alpha}\right)^{\frac{\alpha}{\alpha+\beta}}q^{\frac{1}{\alpha+\beta}}. \tag{3}$$

Plugging these back into the cost function and rearranging gives

$$C(w_1,w_2,q)=w_1x_1(w_1,w_2,q)+w_2x_2(w_1,w_2,q) \tag{4}$$

$$C(w_1,w_2,q)=A^{\frac{\delta}{\alpha+\beta}}q^{\frac{1}{\alpha+\beta}}\theta w_1^{\frac{\alpha}{\alpha+\beta}}w_2^{\frac{\beta}{\alpha+\beta}} \tag{5}$$

where $\theta=\left(\frac{\alpha}{\beta}\right)^{\frac{\beta}{\alpha+\beta}}+\left(\frac{\beta}{\alpha}\right)^{\frac{\alpha}{\alpha+\beta}}$ is just a parameter.

The average cost per kilometer can then be obtained by simply dividing the cost function by the kilometers of road built:

$$\frac{C(w_1,w_2,q)}{q}=A^{\frac{\delta}{\alpha+\beta}}q^{\frac{1-(\alpha+\beta)}{\alpha+\beta}}\theta w_1^{\frac{\alpha}{\alpha+\beta}}w_2^{\frac{\beta}{\alpha+\beta}}. \tag{6}$$

We can use (6) to test several hypotheses. Only the second term in equation (6) depends on q, and $\alpha+\beta$ indicates returns to scale in construction projects. If $\alpha+\beta>1$, $\frac{\partial(\frac{C(w_1,w_2,q)}{q})}{\partial q}<0$ so that an increase in the quantity of road produced will lower average costs. Unit costs are lower in countries in which the price of labor is low. Similarly, unit costs will depend on the price of capital. Given that developing countries often have to import machinery and equipment, we expect the price of capital to be higher in countries facing high transportation costs.

We use $A^{\frac{\delta}{\alpha+\beta}}$ to examine two dimensions of the environment in which a construction firm operates which potentially affect their costs: state fragility and corruption. Firms operating in a conflict or post-conflict country have to take into account the risks associated with termination of their contract, expropriation, and default on the side of the government to deliver their obligations of the contract. Assume that the cost function for this typical road in equation (6) gets shifted by an amount $A^{\frac{\delta}{\alpha+\beta}}$. Alternatively, if the firm needs to pay a bribe to government officials to get a construction permit, $A^{\frac{\delta}{\alpha+\beta}}$ can also represent these additional costs. We assume that both A and δ are exogenous to the firm's minimization problem; they are determined by the level of state fragility and corruption prevailing in the country the firm is operating in. Both, bribe payments and the risk premium required by firms to operate in conflict countries will drive up unit costs[3].

We are aware that conflict can also affect prices through changes in the market structure when

[2]The choice of a Cobb-Douglas production function is for expositional simplicity and to shape our thinking, rather than reflecting the precise production technology underlying road work activities.

[3]For example, Compte et al. (2005) argue that "...as firms expect to be paying a bribe, a mechanical effect of corruption is to increase the contract price by an amount corresponding to the anticipated bribe".

firms are driven out of business, or through a price boom following the end of a conflict as demand for reconstruction increases. Further, corruption in the roads sector can be at three levels, with varying effects on efficiency. First, it can take at the level of the government when government officials receive side-payments to either select a contract from a particular firm, or to process documents of the operating firm. This results in higher unit costs and allocative inefficiency if contracts are not awarded to the most competitive firm. Second, individuals working for companies in the construction sector might inflate costs and use part of of these resources to extract side payments for themselves. The higher unit cost in turn decreases the likelihood of the project to be selected ex-ante by lowering the net present value or rate of return. Third, companies might not respect the contracted standards by using fewer or inferior materials. Here we only focus on the first level. We discuss further hypotheses how conflict and corruption affect roads construction costs in the final section as avenues for future research.

It is also worth highlighting several issues relevant to the procurement of roads which we do not consider in our simple model[4]. First, the market structure of the road construction sector and tender procedures affect how many firms will submit bids for a project, thereby determining *ex-ante competition* and the value of bids (Li and Zheng 2009). Second, if firms collude in the tendering phase, they can affect the price of the road contract (Pesendorfer 2000). Third, once a government has signed a contract with a firm for a road construction project, the firm can extract rents from the government, a problem referred to as hold-up in the literature (Board 2011). In the absence of data on the market structure, values of submitted bids for work activities as well as the difference in costs between contracted and actual costs for each work activity, we are not able to uncover these effects. The main rationale for the simple cost minimization framework is to inform our way of thinking about the deeper determinants of costs and input prices in an economy and to serve as a guide for the estimation. We return to market structure, collusion and hold up problems when discussing avenues for further research.

4 Data

We use unit cost data from the Roads Cost Knowledge System (ROCKS), Version 2.3, developed by the World Bank's Transport Unit. Motivated by the lack of comparable information on costs of road work activities across countries, the database was started in 2001 with the aim of developing "an international knowledge system on road work costs - to be used primarily in developing countries - to establish an institutional memory, and obtain average and range unit costs based on historical data that could ultimately improve the reliability of new cost estimates and reduce the risks generated by cost overruns" (World Bank 2006). The focus of this section is on describing the data; we discuss issues due to selection in detail in the next section. The data stems from World Bank financed projects and is collected in collaboration with road agencies in the respective countries using information from Implementation Completion Reports, Pavement Management Systems Review Reports, Works Contracts, Appraisal Reports and Highway Development and Management Studies.

[4]See Moavenzadeh (1978) for a discussion how the construction sector is generally differs from other sectors.

The data collection exercise was first conducted in five pilot countries, Bangladesh, India, Thailand, Viet Nam, Philippines; in 2002 a second set of countries was added including Ghana, Uganda, Poland, Armenia; in 2004, Lao, Kyrgyz, Kazakhstan, Ethiopia, Nigeria, and Serbia and Montenegro were added. As Table 1 shows, the current version of the database contains data from 3,322 work activities in 99 low and middle income countries out of which 23% are located in low income countries[5]. Contracts date between 1984 and 2008, with 82% of contracts taking place between 1996 and 2006. Tables 17 and 18 in the appendix show the distribution of projects by country over time.

Table 1: Complete ROCKS Database for Low and Middle Income Countries

	N	Percent
Low income	780	23.48
Lower middle income	1,352	40.70
Upper middle income	1,190	35.82
Total	3,322	100

Notes: income classification based on World Development Indicators 2012.

The ROCKS database is based on 5 concepts (World Bank 2006). First, to allow for comparability of similar activities, road works are classified into categories: road development works and road preservation works. Within these two categories, projects are further divided into work class, work type and work activity. The detailed list of these sub-categories is presented in Tables 12 and 13 in the appendix. Second, comparisons are made possible through unit costs which are defined either as costs per square meter or costs per km. Third, the ROCKS database defines a minimum data requirement which is required to make the data comparable (e.g. country, date, project or source name, currency, unit cost, work type, cost type). Fourth, to add flexibility, road agencies are able to enter highly recommended data (e.g. predominant work activity, total cost, length and duration, carriage width, terrain type) and optional data (e.g. number of bidders, value of individual bids, unit costs of asphalt concrete, Portland cement concrete). Unit costs include civil works costs such as mobilization, pavement drainage, major structures and line markings; they exclude agency costs such as design, land acquisition, resettlement and supervision. Fifth, these costs are deflated to the year 2000 using the domestic consumer price index, and then converted into US$ using the exchange rate in 2000. Bringing unit costs back to the same reference year and the same currency is crucial to allow for comparison across projects.

Unit costs are provided for programs or sections; a program is a part of a loan or credit, or a number of road sections combined. Sections define unit costs for road works on particular segments of a road. In either case, we have information on the name of the project the program or section is part of. Considering that a range of reports is used for the data collection, 44% of entries are

[5]We exclude duplicates of 31 contracts for which we have the same entry for country, date, cost per km, cost type, work activity, length, width, shoulder and lanes. We also drop two contracts for Reconstruction Bituminous (one in India and one in Bangladesh) for which the recorded costs were US$218 and US$2,289; the median cost of the 595 Reconstruction Bituminous work activities of our database is US$195,516 per km so these two entries are likely to be incorrect.

estimated costs, 27% are contracted costs, and 29% are actual costs. For some projects the database contains costs on all of the three categories. We include all of the available cost data. Unit costs from these different sources often differ by a large extent, so knowledge of the source is critical to compare unit costs. Individual road works activities also sometimes form part of a larger roads project. In order to account for the fact that there might be various costs types for the same projects, as well as various different work activities for the same project, we cluster the standard errors by country to allow for arbitrary correlation of costs within the same country.

Tables 14 to 16 in the appendix show the mean, median, maximum and minimum cost of various work types and work activities for both preservation and development works. The most expensive development work type is a new six lane expressway followed by a four lane expressway, while for preservation works the most expensive work type is concrete pavement restoration followed by strengthening. Zooming one level further in we see that the most expensive development activity has been further classified as a new bituminous six lane expressway, and the most expensive preservation work activity is a concrete slab replacement followed by reconstruction in bituminous and concrete.

Table 2 shows the range of average unit costs for a precisely defined work activity: asphalt overlays between 40 to 59 mm between 1996-1998 and 2006-2008 ranked by the cost in US$ per km. We limit the time window in order not to conflate differences in unit costs with changes in input prices which might affect economies differently. What is striking is that even for a narrowly defined time window and work activity, there are differences in unit costs of a factor between three to four. Using these unit costs, an asphalt overlay for a length of 100 km would cost US$3,300,000 in the Dominican Republic in 1997, compared to US$11,000,000 in Tanzania in 1996, or US$10,500,000 in Pakistan in 1998. Two sources of heterogeneity remain. While costs per square kilometer of a precisely defined work activity in a short time window are likely to be comparable, one could argue that different road widths might contribute to higher unit costs. Table 19 in the appendix shows that the ranking is largely unaffected when using unit costs per square meter in 1996-1998[6]. Second, we pool across different sources of costs here, so the costs could be estimated, contracted or actual costs. However, the difference in unit costs of a factor of three to four is unlikely to be due to just differences in the source of costs[7]. We do not have enough observations for narrow work activities within these different cost types to separately show the differences for a large set of countries. To account for systematic differences across cost types, we have also compared the cost of construction projects, after partialling out the effects of cost types in a regression. The order of countries as well as range of unit costs remains substantively the same.

The database also contains bidding information for a subset of 266 work activities across 35 countries and the 5 regions. The minimum number of bidders is 1 and the maximum number is

[6]Costs per square meter are missing for many observations in 2006-2008, so we only show unit costs of work activities from the earlier period.

[7]Flyvbjerg et al. (2003) finds average cost overruns for roads are about 20% for projects in Europe and North America; Alexeeva et al. (2008) find average cost overruns by country for the DRC, Malawi, Tanzania, Mozambique, Ghana and Nigera to be between 12.05% and 39.72%; Alexeeva et al. (2011) find average cost overruns by country for Georgia, Serbia, Estonia, Armenia, Macedonia, Albania, Azerbaijan and Kazakhstan to be between 6% and 47%.

Table 2: Unit Costs per km of Asphalt Overlays 40 to 59 mm

Country	Cost per km in $1000	Number	Year	Country	Cost per km in $1000	Number	Year
Work activities undertaken between 1996-1998							
Dominican Republic	33.5	1	1997	Argentina	69.7	1	1997
Ghana	42.9	5	1998	Brazil	74.4	1	1998
Lithuania	44.4	1	1996	Argentina	74.9	1	1996
Indonesia	48.5	1	1996	Cameroon	76.8	4	1997
Lithuania	49.7	1	1998	Bangladesh	79.1	26	1998
Mexico	50.7	1	1997	Vietnam	79.6	2	1998
Ghana	52.7	1	1996	Bangladesh	83.6	1	1997
Costa Rica	57.9	1	1996	Panama	84.1	1	1997
Armenia	60.7	1	1997	Nigeria	95.1	1	1997
Brazil	62.5	2	1996	El Salvador	102.2	1	1998
Bolivia	67.4	1	1997	Pakistan	105.0	1	1997
India	68.1	3	1997	Tanzania	111.7	1	1996
Work activities undertaken between 2005-2007							
Paraguay	31.2	1	2005	Botswana	68.0	1	2006
India	35.9	2	2006	Nigeria	73.0	1	2007
Bulgaria	40.7	1	2006	Argentina	76.2	3	2006
Ecuador	41.6	1	2005	Georgia	82.6	1	2006
India	45.6	1	2005	Brazil	82.9	2	2005
Burkina Faso	48.0	1	2007	Georgia	84.9	1	2005
Brazil	55.2	3	2006	Vietnam	85.4	1	2005
Brazil	58.2	1	2007	Macedonia	85.7	1	2007
Thailand	59.5	1	2005	Rwanda	90.6	1	2006
Philippines	60.8	1	2006	Philippines	94.8	1	2005
Bosnia and Herzegovina	61.9	2	2006	Chile	98.9	1	2006
Nepal	63.1	1	2006				

Notes: costs per km of asphalt overlays 40 to 59 mm; all costs are in 2000 US$; number denotes the number of work activities in a given country over which a simple average is taken.

25, with the median being 5 bidders. About 10% of contracts are awarded based on one or two bidders, which is similar to what Alexeeva et al. (2008) find. The value of each submitted bid is available for 188 contracts across 25 countries. The ratio of the maximum bid to the minimum bid varies substantially across countries up to a factor of 16.6 with a median of 1.34. A regression of the ratio of the maximum bid to the minimum bid on region dummies and dummies for the income categories shows that the ratio is about 2.5 lower in middle income countries compared to low income countries, indicating weaker competition in poorer countries. Alexeeva et al. (2008) conclude from their study on 13 countries in Sub-Saharan Africa that the roads sector is dominated by a few companies which undertake large-scale projects and that the highest value of contracts is awarded to Chinese companies.

Table 3 lists the variables we use from the ROCKS database and the main additional variables we have compiled. Table 11 in the appendix shows the descriptive statistics. Measures of corruption and conflict employed in the empirical literature are to varying degrees subjective measures, based on perceptions on individuals working in the private and public sector. To test whether the results are sensitive to the particular measure employed, we use measures from three sources. If we find patterns that are robust across a range of indicators, we are more confident that the results reflect a particular pattern.

Table 3: Description of Main Data and Sources

Variable	Description	Source
Log of Cost	Log of unit cost of a particular road work activity (1984-2008)	ROCKS dataset, World Bank
Estimate	=1 if estimated costs	ROCKS dataset, World Bank
Contract	=1 if contracted costs	ROCKS dataset, World Bank
Actual	=1 if actual costs	ROCKS dataset, World Bank
Flat	=1 if terrain is flat	ROCKS dataset, World Bank
Hilly	=1 if terrain is hilly	ROCKS dataset, World Bank
Mountainous	=1 if terrain is mountainous	ROCKS dataset, World Bank
Rolling	=1 if terrain is rolling	ROCKS dataset, World Bank
Log of Ruggedness	Log of Terrain Ruggedness Index, representing the average ruggedness of a country measured as hundred of meters of elevation difference for grid points 926 meters apart	Nunn and Puga (2012)
Log of Distance to the nearest ice free coast	Log of average distance to nearest ice-free coast (1000 km)	Nunn and Puga (2012)
Log of Rainfall	Log of yearly precipitation in 100s mm	Dell et al. (2012)
Population Density	Population Density (100 people per square km), 1960-2012	World Development Indicators
Log of Surface Area	Log of Surface Area (1,000 square kilometers)	World Development Indicators
Log of GDP	Log of GDP per capita (1984-2008), constant 2000 US$	World Development Indicators
ACD Conflict	=1 if country is in a conflict	Armed Conflict Dataset
WGI Instability	Index of political instability and violence from World governance Indicators (1996-2012), redefined to: -1.26 (lowest) to 2.21 (highest)	World Governance Indicators
TI Corruption	Corruption index from Transparency International, survey 2008, rescaled to 0.1 (lowest corruption), 5.6 (highest corruption)	Transparency International
WGI Corruption	Index of corruption from World Governance Indicators (1996-2012), redefined to: -1.45 (lowest corruption) to 1.6 (highest corruption)	World Governance Indicators
PIMI	Public Investment Management Index, 2011, measured on scale from 0 (worst) to 4 (best)	Dabla-Norris et al. (2011)
Log of DB Contract	Number of days it takes to enforce a contract, from Doing Business Indicators 2007	Doing Business Indicators

First, our most direct measure for conflict episodes comes from the version 4-2012 of the UCDP/PRIO Armed Conflict Dataset, published by the Uppsala Conflict Data Program (UCDP) and the International Peace Research Institute, Oslo (PRIO)[8]. Readers are referred to Gleditsch et al. (2002), Themnér and Wallensteen (2012) and the Dataset Codebook for details. UCPD defines conflict as “a contested incompatibility that concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths” We follow Miguel et al. (2004) and focus on internal armed conflicts between the government and an internal party with and without outside intervention which accounts for 88.5% of the conflicts recorded in the database. We define a project as being carried

[8]The other potential conflict data set is the Correlates of War data set. Due to concerns over transparency and consistency as well as a high threshold of deaths (Miguel et al. 2004) we prefer the Armed Conflict Dataset (ACD).

out in a conflict state if the state is in conflict in the year the road work activity is recorded; a country is likely not to return to full stability after the end of a conflict, so we also create a variable that defines the country as being in a post conflict period for 5 years after the end of a conflict, or until the country reverted back into conflict. There are 187 conflict and post-conflict periods in the countries covered in our data.

Second, we use data from the Worldwide Governance Indicators (WGI) which are based on data from household and firm surveys, commercial business information providers, non-governmental organizations and public sector organizations. Six indicators capture different aspects of governance in 200 countries since 1996. We use the variables on 'control of corruption' and 'political stability and absence of violence/terrorism'. The control of corruption variable measures "perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as 'capture' of the state by elites and private interests" and the variable political stability and absence of violence/terrorism reflects "perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically-motivated violence and terrorism" (Kaufmann et al. 2010). These indicators are measured between -2.5 and 2.5 where higher numbers reflect lower levels of corruption and political instability. We multiply the variables by (-1) and rename the variables 'Corruption' and 'Political Instability' so that higher numbers reflect higher levels of corruption and political instability.

Third, we use Transparency International's 2008 Corruption Perception Index which allocates scores to countries from 1 to 10, where 0 equals the highest level of perceived corruption and 10 equals the lowest level of perceived corruption. We rescale the variable so that 10 is the highest level of corruption. Graf Lambsdorff (2005) and Thompson and Shah (2005) underscore that the Corruption Perception Index is inappropriate for comparison of countries across time, due to changes in methodology as well as data sources underlying the index. We use 2008 because this is the earliest year with the highest number of countries covered. We have also assembled the index for the years 1998-2011 and our results are robust to using the indicator from earlier years (1998-2007) and later years (2009-2012)[9].

[9]A popular source, due to its coverage across countries and time, for perception based data on institutions is the International Crisis Research Group (for example, Alesina and Weder (2002), Fisman and Miguel (2007), Ahmed (2012), Svensson (2005), Wei (2000)). The International Crisis Research Group compiles yearly data on 22 indicators measuring political, financial and economic risk between 1984 and 2012. Corruption is measured from 0 (high corruption) to 6 (low corruption) as a component of political risk. We do not include this measure for several reasons. First, Treisman (2007) has highlighted various questionable scores in the corruption indicator, both in the cross-section of countries as well as jumps in the indicator over time which do not seem correspond to specific country level policies. We highlight some additional peculiarities here. For example, in 2000, Austria had the same level of corruption (a score of 4/6) as Congo, Iran, Libya and the United States. In the same year, Transparency International gives Austria a score of 7.7/10 where 10 is the least corrupt, Congo has it's earliest ranking in 2004 with 2.3/10, Iran gets 3.3/10, Libya has 2.1/10 in 2003, and the United States receives 7.8/10. There are also large discrepancies with the Worldwide Governance Indicators. We divide the set of countries into deciles for the year 2000 where higher deciles correspond to less corruption, and show that the difference in the location of countries is up to 8 deciles. For instance, Ireland ranks in the 10th decile in the WGI score, while it falls into the second decile according to the ICRG's ranking. Contrarily, the Congo falls within the eight percentile in fighting corruption according to the ICRG measure, while it falls into the second lowest percentile of corruption according to the WGI measure. For some countries there are large jumps. For example, in 1989 Niger's corruption measure was with 4 on par with Italy's, dropped to 3 in 1991 and then to 0 in 1997. Kenya's ICRG score dropped from 3.46 in 2003 to 0.5 in 2006. Lebanon's score dropped from 4 in 1995 to 1.75 in 1996. The average of the cross sectional correlation across the full set of countries between 1996-2011 is 0.86, for our sample of low and

The correlation between the WGI political instability indicator and the ACD conflict dummy is 0.58, and the correlation between the Transparency International measure and the WGI corruption measure is 0.81. Both correlations are significant at the 1 percent level. For the empirical analysis we create lagged three year averages of the two WGI measures. The data for our other explanatory variables are described in section 8.1 in the appendix.

5 Estimation and Identification

To obtain an estimable equation, we take logs of equation (6) and get

$$\ln \frac{C(w_1,w_2,q)}{q} = \frac{\delta}{\alpha+\beta}A + \ln\theta + \frac{1-(\alpha+\beta)}{\alpha+\beta}\ln q + \frac{\alpha}{\alpha+\beta}\ln w_1 + \frac{\beta}{\alpha+\beta}\ln w_2. \tag{7}$$

Rewriting average costs $\frac{C(w_1,w_2,q)}{q}$ as c, denoting $\frac{\delta}{\alpha+\beta}=\gamma$, $\frac{1-(\alpha+\beta)}{\alpha+\beta}=\phi_1$, $\frac{\alpha}{\alpha+\beta}=\phi_2$, $\frac{\beta}{\alpha+\beta}=\phi_3$, adding an error term and fixed effects for work activities, time and region as well as subscripts for work activities, work types, countries and time, we obtain

$$\begin{aligned}\ln c_{apit} =& \gamma A_{it} + \ln\theta + \phi_1 \ln q_{apit} + \phi_2 \ln w_{1apit} + \phi_3 \ln w_{2apit} \\ &+ \kappa_{apit} + \omega_a + \tau_t + \xi_{pt} + \rho_{ap} + \epsilon_{apit}\end{aligned} \tag{8}$$

for work activity $a = 1,\ldots,A$, work type $p = 1,\ldots,P$, country $i = 1,\ldots,N$, and time $t = 1,\ldots,T$, where c is the cost per kilometer, q is a dummy variable that is equal to one if the length of the road is above 50 km; we do not have data on the cost of labor and capital for each construction project. Rather than estimating the technological parameters, our controls are selected to control for the deep determinants of factor prices. The cost of capital is going to be a function of transport costs, so we include the distance to the nearest ice-free coast from Nunn and Puga (2012) as a measure of the price of capital and equipment. For about half of the road work activities we know whether the terrain on which the road works are undertaken is flat, mountainous, hilly or rolling. We include these as dummy variables, and additionally include a measure of country-level ruggedness to account for higher input costs required on more rugged terrain. Given that unit costs might be higher in countries with high levels of rainfall, we include the three year average of lagged precipitation. We further include the log of GDP per capita to proxy for the price of labor and capital. We then use our measures of corruption and conflict to proxy for A, and include two dummy variables indicating that a country is above the median level of conflict or corruption of the sample[10]. Due to high levels

middle income countries the average cross sectional correlation is 0.59, ranging from 0.37 in 1998 to 0.70 in 2011. Yearly changes are uncorrelated for 4 periods, with an average correlation of 0.2 for the remaining periods in the full sample and similar patterns in the our sample of countries. Wei (2000) uses an average of the ICRG measure between 1991-1993, and Svensson (2005) uses either an average between 1982-2001 or the year 2001 in a cross section of countries. Given that cross-sectional variation is rather high, in these settings different measures produce similar results. Using these measures in a panel setting has been seriously questioned (Treisman 2007; Graf Lambsdorff 2005). Alesina and Weder (2002) use five-year averages for their main results, but emphasize that results in first differences should be interpreted 'very cautiously'. Ahmed (2012) does not show the robustness of his results when using alternative measures of corruption in his regressions using country fixed effects. Finally, Graf Lambsdorff (2005) notices that the ICRG Corruption variable reflects the *political risk* associated with corruption, rather than a country's level of corruption; the ICRG website does not provide information on how the scores are constructed. We therefore rely on the WGI and the TI corruption measures.

[10]We take the median of distinct country-year observations we have in the sample.

of correlation between these measures, we enter them in separate regressions. Appreciating that road work contracts require a substantial amount of time to negotiate, we lag time varying country level controls by one period.

To account for differences in the source of unit costs and procurement, κ_{apit} is a vector of dummy variables capturing whether the source of costs is estimated or contracted costs with the base category being actual costs. All models include work activity fixed effects ω to control for systematic differences in costs across work activities, year fixed effects τ to account for worldwide construction industry trends, interaction terms between work type and 5-year dummies ξ to allow for differences in the evolution of costs for different work types, region fixed effects ρ, and an error term ϵ[11]. We have missing values for certain countries for some of the explanatory variables. In this case, we follow a procedure known as modified zero-order regression outlined by (Greene 2003, p.60) in which we include a dummy variable that is equal to one if the variable is missing, and replace the missing observations with zero. We are not interested in the coefficients of the missing dummy variables, so do not report them when discussing the results.

In order to interpret the coefficient estimates on the included variables as causal relationships, we would require that $E(X_{apct}|\epsilon_{apit} = 0)$ where X_{apit} denotes a vector of all included controls. This is an implausible assumption. While it is unlikely that there is reverse causality from unit costs to the control variables, omitted variables might still bias our parameter estimates. Unfortunately, many of the controls are time invariant, and we do not have enough variation over time to include country fixed effects to account for time invariant unobservable characteristics and still identify the coefficient estimates of time-varying variables. The parameters estimates should therefore be interpreted as statistical associations, which still contain valuable insights. As a robustness check we will also estimate equation (8) with country fixed effects to test whether the road work activity characteristics, which have substantial within country variation, remain significant.

5.1 Selection

Our unit cost sample is selected along three dimensions. First, we only observe road work activities for which the World Bank provided a loan[12]. Given that this is the only available large database, our findings need to be interpreted in the context of this subset of work activities conducted in collaboration with the World Bank.

Second, from inspection of tables 17 and 18 in the appendix it becomes clear that the distribution of road work activities is not a random sample of contracts per country for each year. Rather,

[11]Table 20 in the appendix shows the coefficients of the work type dummy variables including and excluding country level controls. In the discussion of the results in the next section, we always control for work activity fixed effects, but do not discuss the differences in unit costs across these categories as this is not the main focus of this paper.

[12]It is not clear in which direction this would bias our estimates. If the World Bank, through its procurement guidelines, is able to impose stricter procedures in more corrupt countries than the government, we would underestimate the effect of corruption. Without the stringent guidelines, the government would have to pay a higher premium in high corruption countries. On the other hand, governments in corrupt countries are potentially better able to limit the magnitude of side payments necessary to carry out a work activity; this would indicate that our estimates of the effect of corruption are higher than the cost faced by governments.

as mentioned in section 4, the data are clustered around pilot countries, with additional countries being added gradually. We have been told from the responsible for the database that selection into the database out of the population of projects carried out by the World Bank does not follow any specific pattern, so that we regard it as random. To capture time invariant unobservables determining selection as a pilot country, we also include a dummy variable that is equal to one if a country belongs to the first two sets of pilot countries[13].

Third, we only observe costs for projects that were implemented, so out of the population of potential road work activities we miss projects which have not been started[14]. Considering that the net present value of a project at time=0 is $NPV_0 = -I_0 + (B_1 - C_1)/(1+r)^1 + \ldots + (B_T - C_T)/(1+r)^T$, projects which appear in the database must have low enough costs (initial costs I_0 as well as maintenance costs C) or high enough benefits B. We therefore observe a truncation of the response variable (those with high project costs and low benefits). We can examine the bias introduced by such truncation. Assume that the true model is $c = \beta_0 + \beta_1 x + u$ where c are unit costs, β_0 is a constant, β_1 is our coefficient of interest, and u is an error term. Consider a project with the same level of benefits in two countries. Let x be corruption, assume that corruption increases costs so that $\beta_1 > 0$, and that one country has a high level of corruption, while the other country has a low level of corruption. While the project is undertaken in the low corruption country, it might fail to generate a high enough NPV in the high corruption country. We therefore miss projects with high x and high u. Thus, thus x and u will be negatively correlated in the truncated sample and the OLS estimate of β_1 will be downward biased (towards zero), *underestimating* the effect of corruption on unit costs. Similarly, assume that x is a measure of flatness of the terrain, so that higher values correspond to flatter terrain, and lower values to mountainous terrain. Since it is cheaper to build a road on flat terrain, $\beta_1 < 0$. Consider again a project yielding the same level of benefits in a flat and in a mountainous country. Following the logic above, a project yielding the same benefits is more likely to be in our sample in flat terrain (high x) and we will tend to miss out on projects in mountainous areas, so that x and u will be positively correlated in the truncated sample and the OLS estimate of β_1 will be upward biased, i.e. again towards zero. In this case, we will underestimate the cost-reducing effect of flat terrain. This suggests that we will tend to underestimate effects in general so that our estimates can be viewed as conservative. If the benefits of a project are a function of the individuals affected by the improved road, and congestion costs are important, we would expect the benefit of transport infrastructure to be higher in densely populated areas, so that projects are more likely to be selected even if costs are higher than in an otherwise equivalent context. Unfortunately, we do not have information on projects which have not been carried out. We are therefore limited to controlling for population density to account for selection on observables.

6 Empirical Results and Discussion

We start by presenting the main results from equation (8) including our measures of conflict, and then turn to corruption in the second set of results. We examine the correlations with these mea-

[13]These countries are Armenia, Bangladesh, Ghana, Philippines, Thailand, Uganda, Vietnam, India.

[14]For work activities in the sample for which we have estimated or contracted costs, we do not have information whether they were completed.

sures separately, because they are highly correlated, and the effect of conflict holding corruption constant, and vice versa, is difficult to identify, and not the object of interest. Columns (1)-(3) in table 4 include the conflict variables without controls for GDP per capita, columns (4)-(6) include GDP per capita for one year before the road work activity (we refer to this as contemporaneous GDP per capita), and columns (7)-(9) include predetermined GDP per capita in 1985. While GDP per capita in the year of the road work activity is a more precise proxy for factor prices, it is likely to be correlated with other contemporaneous variables affecting unit costs. Therefore, we also show the results controlling for GDP per capita in 1985.

There is a robust and significant relationship between violent conflict and its legacy and unit costs. Countries which are in conflict have about 30% higher unit costs. Although the coefficient on the post-conflict dummy is positive, it is not significantly different from zero. We find evidence for the higher costs in politically unstable countries also when using the political instability measure from the Worldwide Governance Indicators (where we use the continuous measure as well as a dummy variable for whether the measure is above the median of the sample). Countries which are above the median of the sample in terms of political instability, face about 13% higher costs. The size and significance of the coefficients is robust to omitting GDP per capita, or controlling for contemporaneous or predetermined GDP per capita. The magnitude of the effect appears in line with Benamghar and Iimi (2011), who find that halving security incidents would reduce procurement costs by 10% and cost overruns by 15%.

Unsurprisingly, geography matters. The ruggedness of the terrain in a country, surface area and population density of a country are significantly and positively associated with unit costs. Building a road in a more rugged terrain is likely to involve higher unit costs of construction and maintenance. Column (1) suggests that a one percent increase in the ruggedness of a country is associated with about 0.09 percent higher unit costs. The surface area and distance to the nearest ice-free coast are collinear, so that when we include the surface area we cannot estimate the coefficient on the distance to the nearest ice-free coast precisely anymore. The positive coefficient on the surface area therefore is likely to pick up both the effects of being landlocked, leading to higher transport costs, as well as the fact that perhaps constructing and maintaining roads in larger countries involves higher organizational costs. Population density is also positively and significantly associated with unit costs, indicating that unit costs rise by about ten percent for an increase of 100 people per square kilometer. Finally, we turn to the work activity specific control variables. The estimates suggest that there are significant economies of scale. Unit costs are about ten percent lower when road work activities cover a length of at least 50 km. This is close to an estimate by AFRICON (2008) who find that median unit costs are 15-20% lower for road contracts that are larger than 50 km. There is no evidence that estimated costs and actual costs are significantly different[15]. There is

[15]Unfortunately, data on the type of procurement is missing for more than half of the sample. For the unit costs for which we have data, the procurement was done by international competitive bidding in 62%, national competitive bidding in 36%, with the remaining 26 work activities procured via single source selection, force account or limited international bidding. We have also tried including a dummy variable that is equal to one if procurement was done via international competitive bidding and zero otherwise, as well as a dummy variable that is equal to one if we miss procurement information. The results suggest that work activities awarded through an international auction have 35-38% higher costs (significant at the 5 percent level) compared to national bidding process, single source selection or

some evidence that contracted and estimated costs are lower than actual costs, but the effect is not significantly different from zero.

We now turn to corruption in table 5. As before, columns (1)-(3) exclude the control for GDP per capita, columns (4)-(6) include contemporaneous GDP per capita, and columns (7)-(9) include the lagged GDP per capita. The pattern is consistent for the corruption variables from Transparency International and the Worldwide Governance Indicators. We find that Transparency International's measure of corruption is significantly correlated with unit costs, so that a one point increase in corruption on a ten-point scale is associated with an increase in costs by about 6-7%. The WGI measure suggests that moving a country from the 75th percentile of corruption to the 25th percentile of corruption is associated with 6.3% lower unit costs. Unit costs in countries with a level of corruption above the median as measured by the Worldwide Governance Indicator indicator of corruption have on average 12% higher costs[16]. The effects of the other control variables are stable when comparing their coefficients and standard errors with table 4.

Table 21 in the appendix shows a model without controls for conflict and corruption, and some of the omitted controls which are still of interest. Pilot countries have on average lower costs, but the coefficient is not significantly different from zero. There is substantial regional variation. Unit costs in East Asia and the Pacific, Latin America and the Carribean, the Middle East and North Africa, and South Asia are all significantly lower than in costs in the base category, Sub-Saharan Africa. These differences in costs range between the 49% lower costs in East Asia and the Pacific, to 18% lower costs in Latin America and the Caribbean. Subsequently, we use column (1) of table 21 to explore omitted variables.

force account. Alexeeva et al. (2008) find, when analyzing 109 contracts in 13 Sub-Saharan African countries, that local firms have a cost advantage over international firms, likely due to lower management and overhead costs. However, local firms perform worse in the implementation of the project, including longer delays and higher cost overruns. We do not have data related to the implementation of the project, so we cannot test whether we find the same with our data.

[16]We also tested whether estimated or contracted costs are significantly lower compared to actual costs in countries which suffer from conflicts, or countries with high levels of corruption, but we do not find any evidence for this.

Table 4: Conflict

	ACDI	WGII	WGImedI	ACDII	WGIII	WGImedII	ACDIII	WGIIII	WGImedIII
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ACD Conflict	0.306***			0.308***			0.31***		
	(0.064)			(0.069)			(0.064)		
ACD Post-Conflict	0.04			0.033			0.054		
	(0.057)			(0.058)			(0.055)		
WGI Instability		0.086*			0.083			0.096**	
		(0.045)			(0.051)			(0.046)	
WGI Instability > Median			0.135**			0.13**			0.153**
			(0.06)			(0.065)			(0.061)
Log Ruggedness	0.086***	0.129***	0.128***	0.082***	0.127***	0.126***	0.088***	0.13***	0.125***
	(0.029)	(0.034)	(0.033)	(0.029)	(0.035)	(0.034)	(0.028)	(0.035)	(0.033)
Log of Rainfall	-.088	-.070	-.072	-.104	-.080	-.083	-.093	-.082	-.091
	(0.065)	(0.071)	(0.07)	(0.065)	(0.072)	(0.071)	(0.065)	(0.07)	(0.071)
Log dist to coast	-.010	-.031	-.030	-.021	-.040	-.042	-.003	-.025	-.031
	(0.041)	(0.047)	(0.047)	(0.044)	(0.05)	(0.049)	(0.042)	(0.047)	(0.046)
Population Density	0.122***	0.102***	0.097***	0.118***	0.099***	0.094***	0.125***	0.105***	0.097***
	(0.018)	(0.019)	(0.017)	(0.019)	(0.019)	(0.018)	(0.018)	(0.019)	(0.017)
Log of Surface Area	0.052**	0.07***	0.075***	0.058**	0.075***	0.083***	0.05**	0.067***	0.075***
	(0.021)	(0.022)	(0.021)	(0.023)	(0.025)	(0.023)	(0.022)	(0.023)	(0.021)
Length > than 50km	-.116***	-.090**	-.094**	-.127***	-.098**	-.104***	-.118***	-.092**	-.100**
	(0.036)	(0.039)	(0.038)	(0.036)	(0.04)	(0.038)	(0.037)	(0.04)	(0.039)
Estimate	-.025	-.026	-.028	-.019	-.020	-.024	-.020	-.021	-.023
	(0.056)	(0.058)	(0.058)	(0.055)	(0.057)	(0.057)	(0.055)	(0.058)	(0.057)
Contract	-.074	-.079	-.086	-.076	-.081	-.089*	-.070	-.076	-.085
	(0.055)	(0.054)	(0.054)	(0.055)	(0.054)	(0.054)	(0.054)	(0.053)	(0.053)
Log of GDP per capita				-.038	-.032	-.041			
				(0.037)	(0.041)	(0.04)			
Log of GDP pc (1985)							0.004	0.002	-.017
							(0.044)	(0.045)	(0.043)
Obs.	3322	3322	3322	3322	3322	3322	3322	3322	3322
R^2	0.898	0.896	0.896	0.898	0.896	0.896	0.898	0.896	0.896

Notes: Dependent variable is the log of cost per km; all models control for work activity fixed effects, year fixed effects, an interaction between work type and 5-year period fixed effects and region fixed effects; base categories are actual costs; robust standard errors in parentheses, clustered at the country; *, **, *** denote significance at 10%, 5% and 1% levels.

Table 5: Corruption

	TI	WGI	WGImed	TIII	WGIII	WGImedII	TIIII	WGIIII	WGImedIII
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
TI Corruption	0.063*** (0.023)			0.062** (0.025)			0.076*** (0.025)		
WGI Corruption		0.084** (0.043)			0.072 (0.052)			0.101** (0.043)	
WGI Corruption > Median			0.122** (0.051)			0.112* (0.064)			0.142*** (0.051)
Log Ruggedness	0.137*** (0.034)	0.149*** (0.033)	0.147*** (0.032)	0.135*** (0.035)	0.146*** (0.034)	0.146*** (0.033)	0.137*** (0.035)	0.151*** (0.034)	0.152*** (0.033)
Log of Rainfall	-.059 (0.07)	-.049 (0.066)	-.038 (0.069)	-.068 (0.071)	-.058 (0.067)	-.045 (0.07)	-.076 (0.071)	-.061 (0.067)	-.043 (0.069)
Log dist to coast	-.051 (0.05)	-.039 (0.048)	-.044 (0.047)	-.055 (0.052)	-.048 (0.051)	-.049 (0.05)	-.048 (0.05)	-.036 (0.048)	-.035 (0.046)
Population Density	0.09*** (0.019)	0.098*** (0.019)	0.089*** (0.018)	0.087*** (0.02)	0.096*** (0.019)	0.088*** (0.019)	0.09*** (0.019)	0.099*** (0.019)	0.091*** (0.018)
Log of Surface Area	0.083*** (0.022)	0.085*** (0.021)	0.092*** (0.022)	0.085*** (0.024)	0.091*** (0.023)	0.095*** (0.023)	0.081*** (0.022)	0.084*** (0.022)	0.09*** (0.022)
Length > than 50km	-.088** (0.038)	-.091** (0.038)	-.096** (0.038)	-.093** (0.039)	-.100** (0.039)	-.102*** (0.039)	-.090** (0.04)	-.093** (0.04)	-.097** (0.04)
Estimate	-.030 (0.058)	-.031 (0.059)	-.022 (0.058)	-.025 (0.057)	-.026 (0.058)	-.018 (0.057)	-.026 (0.058)	-.028 (0.058)	-.018 (0.057)
Contract	-.086 (0.055)	-.080 (0.054)	-.076 (0.053)	-.087 (0.054)	-.083 (0.054)	-.078 (0.053)	-.084 (0.053)	-.078 (0.053)	-.071 (0.052)
Log of GDP per capita				-.018 (0.041)	-.038 (0.043)	-.024 (0.047)			
Log of GDP pc (1985)							0.0007 (0.044)	0.0009 (0.045)	0.017 (0.047)
Obs.	3322	3322	3322	3322	3322	3322	3322	3322	3322
R^2	0.896	0.896	0.896	0.896	0.896	0.896	0.897	0.896	0.896

Notes: Dependent variable is the log of cost per km; all models control for work activity fixed effects, year fixed effects, an interaction between work type and 5-year period fixed effects and region fixed effects; base categories are actual costs; robust standard errors in parentheses, clustered at the country; *, **, *** denote significance at 10%, 5% and 1% levels.

6.1 Robustness

We now perform a number of robustness checks on our results. First, we introduce country fixed effects in table 6. This is a very limited test because most of our variables are country-specific and so drop out. As Kaufmann et al. (2010) point out, most countries in the Worldwide Governance Indicators have high persistence in these indicators over time, and changes in indicators are both due to changes in measurement as well as in the performance of a country. However, we have within country level variation in the conflict variable due to the different timing of the road work activities and conflicts, and this variable does not suffer from changes in measurement. The coefficients on those variables that can be tested are not significantly affected. The scale effect remains significant, negative, higher in magnitude, and coincides even closer with AFRICON (2008) findings. The coefficient on the conflict variable remains significant and positive but slightly lower in size, suggesting that countries undertaking road works during times of violence face 21% higher costs.

Table 6: Robustness Checks

	FE1	FE2
	(1)	(2)
Estimate	0.007	0.008
	(0.059)	(0.059)
Contract	-.056	-.051
	(0.056)	(0.056)
Length > than 50 km	-.129***	-.128***
	(0.038)	(0.038)
ACD Conflict		0.213*
		(0.114)
ACD Post-Conflict		0.064
		(0.104)
Obs.	3322	3322
R^2	0.908	0.908

Notes: Dependent variable is the log of cost per km; all models control for work activity fixed effects, year fixed effects, an interaction between work type and 5-year period fixed effects and region fixed effects; base categories are actual costs; robust standard errors in parentheses, clustered at the country; *, **, *** denote significance at 10%, 5% and 1% levels.

Second, we also estimate the models with costs per square meter instead of costs per km and find that the results are substantively the same. We prefer to use costs per km as we loose 500 observations when using the cost per square meter. Third, instead of the three-year lagged average of the WGI measures, we also use the variable in the year before the road work activity, as well as taking 5-year averages; the results are not affected. Fourth, one concern with the ACD conflict measure is that it has a cut-off of at least 25 battle-related deaths so that we might be picking up conflicts in remote areas in large countries which do not actually affect the whole country. To test whether this is driving the results, we interact the conflict and the post conflict dummy variables with the size of the country. We perform a joint significance test on these two interaction terms and find that we fail to reject the null hypothesis that they are jointly equal to zero, suggesting that this is not driving the results.

6.2 Omitted Variables

Having established that conflict and corruption are associated with higher costs, our main concern that prevents us from interpreting the coefficient estimates as causal are omitted variables. We have shown that the inclusion of per capita GDP does not substantially alter the results, which suggests that conflict and corruption are correlated with unit costs not simply through the level of income. However, conflict and corruption might be correlated with other unobserved variables. For example, conflict states are likely to both have weak government public investment management capacity, as well as an unfriendly business environment. We therefore use information on the Public Investment Management Index and data from the Doing Business Indicators in 2007 to test whether these two dimensions capture part of the higher costs. We use variables which are underlying the Business Indicators: the time it takes to start a business, obtain a construction permit, import and export, register property, and enforce a contract. The Public Investment Management Index is measured on a scale from 1 to 4, with higher values reflecting better public investment management capacity. If our results are not affected by their inclusion, this does not imply a causal relationship, but it weakens the argument that our conflict and corruption variables are simply proxying for a weak business environment and government capacity. Table 7 shows the coefficients on these variables when added in separate regressions to the base model in column (1) of table 21. The only significant correlation between costs is with time it takes to enforce a contract. A 10% increase in the number of days it takes to enforce a contract is associated with 4.4% higher unit costs. The coefficient on the Public Investment Management Index (PIMI) is insignificant but negative, suggesting that a one unit increase in the PIMI is associated with 3.1% lower unit costs. As we would like to test both a measure for the capacity of the government as well as the private sector environment, we now test whether the inclusion of these two measures affects our coefficients on conflict and corruption.

Table 7: Omitted Variables

Public Investment Management Index	-.031 (0.068)
Log of DB Start Business	0.091 (0.059)
Log of DB Construction Permit	-.014 (0.076)
Log of DB Import+Export	0.083 (0.095)
Log of DB Register Property	0.004 (0.03)
Log of DB Enforce Contract	0.436*** (0.1)

Notes: Base model from column (1) of table 21. Each entry represents a separate regression; robust standard errors in parentheses, clustered at the country; *, **, *** denote significance at 10%, 5% and 1% levels.

Table 8 presents the results for conflict, where the upper panel includes the Public Investment Management Index, and the lower panel includes the Doing Business variable measured as the log of the number of days it takes to enforce a contract. Contemporaneous GDP per capita and lagged GDP per capita are again added gradually to test the sensitivity of the results to its inclusion. All models also include for the baseline controls from the previous tables.

Table 8: Conflict - Omitted Variables

	ACDI	WGII	WGImedI	ACDII	WGIII	WGImedII	ACDIII	WGIIII	WGImedIII
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ACD Conflict	0.308*** (0.067)			0.313*** (0.07)			0.311*** (0.066)		
ACD Post-Conflict	0.038 (0.06)			0.034 (0.059)			0.051 (0.057)		
WGI Instability		0.088* (0.05)			0.089* (0.054)			0.098** (0.049)	
WGI Instability > Median			0.14** (0.069)			0.143** (0.071)			0.161** (0.068)
Public Investment Management Index	-.010 (0.055)	-.001 (0.065)	0.005 (0.067)	0.006 (0.059)	0.013 (0.068)	0.023 (0.069)	-.018 (0.058)	-.006 (0.067)	0.007 (0.069)
Log of GDP per capita	NO	NO	NO	YES	YES	YES	NO	NO	NO
Log of GDP pc (1985)	NO	NO	NO	NO	NO	NO	YES	YES	YES
Obs.	3322	3322	3322	3322	3322	3322	3322	3322	3322
R^2	0.898	0.896	0.896	0.898	0.896	0.896	0.898	0.896	0.896
ACD Conflict	0.256*** (0.06)			0.259*** (0.064)			0.261*** (0.06)		
ACD Post-Conflict	0.047 (0.058)			0.04 (0.059)			0.057 (0.056)		
WGI Instability		0.082** (0.036)			0.083** (0.041)			0.089** (0.036)	
WGI Instability > Median			0.118** (0.051)			0.115** (0.056)			0.131** (0.052)
Log of DB Enforce Contract	0.344*** (0.081)	0.423*** (0.087)	0.416*** (0.088)	0.348*** (0.083)	0.428*** (0.089)	0.421*** (0.09)	0.325*** (0.084)	0.402*** (0.091)	0.395*** (0.093)
Log of GDP per capita	NO	NO	NO	YES	YES	YES	NO	NO	NO
Log of GDP pc (1985)	NO	NO	NO	NO	NO	NO	YES	YES	YES
Obs.	3322	3322	3322	3322	3322	3322	3322	3322	3322
R^2	0.899	0.898	0.898	0.899	0.898	0.898	0.899	0.898	0.898

Notes: Dependent variable is the log of cost per km; all models control for work activity fixed effects, year fixed effects, an interaction between work type and 5-year period fixed effects and region fixed effects, dummy variables for actual and contracted costs, type of terrain, ruggedness, distance to the nearest ice-free coast, population density, log of surface area, dummy for lenght>50 km; robust standard errors in parentheses, clustered at the country; *, **, *** denote significance at 10%, 5% and 1% levels.

The coefficient on the Public Investment Management Index is never significantly different from zero and it's inclusion does not affect the size and significance of the conflict variables. The business environment reveals a more consistent correlation with road works costs. A 10% increase in the number of days it takes to enforce a contract, is associated with a 2-4% increase in unit costs, and the results are robust to including contemporaneous and lagged GDP per capita or excluding GDP per capita. Its inclusion slightly reduces the size of the conflict variables. The most direct measure of conflict from the ACD drops in size from a premium of 30.6% to 25.6% in column (1) when accounting for the business environment. The Worldwide Governance Indicator measure also slightly drops in size from 14% higher costs for countries above the median of political instability to 12% in column (3). The results are not sensitive to the inclusion of contemporaneous or lagged GDP per capita.

Table 9 shows the same exercise for corruption. Both the inclusion of the Public Investment Management Index and the Doing Business variable do not substantively affect the size nor the significance of the coefficients, suggesting that there is a significant association with corruption after controlling for the business environment and the public investment capacity. Overall, the findings suggest that our measure of the business environment explains some of the premium charged by firms operating in conflict countries with little effect of either of the two measures on corruption.

Table 9: Corruption - Omitted Variables

	TI	WGI	WGImed	TIII	WGIII	WGImedII	TIIII	WGIIII	WGImedIII
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
TI Corruption	0.062***			0.062**			0.076***		
	(0.024)			(0.025)			(0.025)		
WGI Corruption		0.076*			0.068			0.093**	
		(0.044)			(0.051)			(0.044)	
WGI Corruption > Median			0.12**			0.113*			0.138***
			(0.053)			(0.064)			(0.053)
Public Investment Management Index	-.014	-.025	-.005	-.007	-.014	0.002	-.019	-.030	-.012
	(0.063)	(0.064)	(0.064)	(0.067)	(0.066)	(0.066)	(0.066)	(0.066)	(0.066)
Log of GDP per capita	NO	NO	NO	YES	YES	YES	NO	NO	NO
Log of GDP pc (1985)	NO	NO	NO	NO	NO	NO	YES	YES	YES
Obs.	3322	3322	3322	3322	3322	3322	3322	3322	3322
R^2	0.896	0.896	0.896	0.896	0.896	0.896	0.897	0.896	0.896
TI Corruption	0.06***			0.062***			0.07***		
	(0.02)			(0.023)			(0.021)		
WGI Corruption		0.096**			0.093*			0.108**	
		(0.042)			(0.053)			(0.043)	
WGI Corruption > Median			0.13***			0.127**			0.145***
			(0.048)			(0.06)			(0.049)
Log of DB Enforce Contract	0.425***	0.442***	0.442***	0.429***	0.446***	0.446***	0.396***	0.423***	0.42***
	(0.092)	(0.097)	(0.102)	(0.093)	(0.099)	(0.104)	(0.095)	(0.101)	(0.105)
Log of GDP per capita	NO	NO	NO	YES	YES	YES	NO	NO	NO
Log of GDP pc (1985)	NO	NO	NO	NO	NO	NO	YES	YES	YES
Obs.	3322	3322	3322	3322	3322	3322	3322	3322	3322
R^2	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898

Notes: Dependent variable is the log of cost per km; all models control for work activity fixed effects, year fixed effects, an interaction between work type and 5-year period fixed effects and region fixed effects, dummy variables for actual and contracted costs, type of terrain, ruggedness, distance to the nearest ice-free coast, population density, log of surface area, dummy for lenght>50 km; robust standard errors in parentheses, clustered at the country; *, **, *** denote significance at 10%, 5% and 1% levels.

6.3 How do Costs affect Provision?

The core of this paper has been to investigate the relationship between unit costs, conflict and corruption. Finally, we investigate whether higher unit costs are associated with lower outcomes as measured by the log of kilometers of roads paved per person and the performance of a country in the quality of trade and transport related infrastructure index which as measured between one and five[17] (Arvis et al. 2007). As road work activities are heterogenous, we first want to net out variation that is related to the road work activity, time effects as well as region fixed effects. We can then use the residual of this cost regression as a measure of residual unit costs and use it as a control in a regression of provision on unit costs, and a vector of controls. We prefer to directly estimate the coefficient by regressing the outcome measure on unit costs, while controlling for the vector of controls employed in the baseline regression in column (1) of table 21. Table 10 shows

Table 10: Correlation between Unit Costs and Infrastructure Provision

	pavedroad	infrastructure
	(1)	(2)
Log of Cost per km (2000 US$)	-.068**	-.042**
	(0.028)	(0.017)
Obs.	3322	3269
R^2	0.681	0.668

Notes: Dependent variable as follows: log of km of paved road per person in column (1); quality of trade and transport related infrastructure index in column (2); both equations include all controls employed in column (1) of table 21; standard errors are clustered at the country level; *, **, *** denote significance at 10%, 5% and 1% levels.

the correlation between unit costs and transport infrastructure outcomes. We find evidence that higher costs are associated with a worse infrastructure. A ten percent increase in unit costs is associated with a 0.68% reduction in the kilometers of paved roads per person in a country and a 0.4 reduction in the quality of trade and transport related infrastructure index component of the logistics performance index. At the median value (2.23) this change corresponds to a move almost into the top quartile. The regression in table 10 includes the same controls as column (1) of table 21, but the results remain the same when we control for contemporaneous per capita GDP or per capita GDP in 1985.

6.4 Future Research

This section reviews our core results and discusses avenues for further research, drawing on some recommendations outlined in World Bank (2011a). First, one possible area of future research is to examine the mechanisms through which state fragility affects costs. In this paper, we modeled this in the cost function as a premium that firms require to cover costs due to disruption and risk. However, an alternative explanation is that fewer firms are left in the market after conflicts as they get driven out of business; if the supply of firms providing road works decreases by more than the contraction of demand, this will lead to higher prices. In this context, a combination of insuring

[17] The measure is continuous and bounded between one and five.

risks of construction firms in fragile states and lifting of constraints to firms entering the construction sector might be helpful to increase competition and to reduce unit costs. Little is known also about the evolution of prices in post-conflict settings when investment accelerates so that there is increased pressure on the construction sector, foreign companies are eager to enter the new market and there might be delays in tendering due to aid conditionalities[18]. Here the effect is ambiguous: if the growth in demand outstrips the growth in supply, prices will increase; if large foreign companies, which are able to operate on losses in the short run, undercut prices in order to enter a market, this might even lead to lower prices.

Second, our results present evidence that there is a correlation between corruption and unit costs and our simple theoretical framework assumed that this is due to bribe payments to officials to obtain permits. A main drawback of perception based measures is that they might reflect overall governance quality of a country rather than being specifically related to the level of corruption (Kenny 2009). Olken (2009) finds that for road projects in Indonesia, although perceptions are correlated with his estimate for corruption, the correlation is fairly weak. Country level perception measures also do not allow us to distinguish between the levels of corruption across different sectors, petty corruption vs grand corruption, cartellization of the industry, or misreporting of expenditures. Sector specific measures of corruption from firm level surveys would allow establishing a tighter link between corruption and unit costs of transport infrastructure as well as the extent of corruption.

Missing expenditures and inferior inputs are a serious concern not only affecting the cost of construction but also subsequent maintenance costs for the government. For example, an audit of 18 road contracts by the Government of Zambia found that 50% of samples used weaker cement than required, 75% of samples had more clay content than required and all samples indicated use of substandard cement (Government of Zambia 2010). To our knowledge, the only study that systematically tests ways to reduce missing expenditures in the context of the roads sector is Olken (2007), who finds that increasing the audit probability by the government from 4 to 100% reduced missing expenditures by 8%. The audit treatment was significantly more effective than increasing community participation in the monitoring process. However, he also finds that in villages that were exposed to the audit experiment, a higher number of jobs was given to family members of project officials, suggesting that corruption might have been shifted. World Bank (2011a) suggest alternative mechanisms, including strengthening the Engineer[19] and checking the wealth of key procurement agency officials. We are not aware of evidence on the effectiveness of these various policies. Countries could also experiment with different incentive contracts for the engineer to incentivize reporting of corruption and fraud, as well as recruitment of the engineer based on reputation of honesty rather than simply based on price. The collection of a sample of each contracted road work activity by an engineer to estimate costs and verify contracted materials could

[18]The issues associated with the positive demand shock also apply to countries experiencing windfalls from natural resources that trigger spending booms.

[19]Projects financed by the World Bank usually require an Engineer, who takes on the supervision of the contractor (World Bank 2012); for larger projects this can be a supervisory firm. The Engineer is an expert in the design of the project and expected to oversee the complete implementation, ensuring that quality and implementation are as stipulated in the contract (World Bank 2011a).

be part of a construction contract. Countries could then experiment with these various policies at a sub-national level to investigate their effectiveness in reducing missing expenditures and the use of substandard materials.

Third, an important area this paper did not tackle due to data limitations is the market structure of the local construction industry and collusion among construction sector firms[20]. World Bank (2011a) estimate that the overcharge due to cartels leads to about 40% higher prices on average in developing countries. Given the magnitude of these effects, limiting collusion is a first order concern to ensure efficiency of public spending. The report highlights that cartellization of the construction sector is not distinctive to developing countries: cartels in the roads and construction sector were found in the United states, Denmark, France, Germany, Japan and Sweden[21]. This does not imply that governments in developing countries with weaker detection technologies should give up on detecting collusion, but it is important to keep in mind that this is a problem when government capacity is high. World Bank (2011a) suggest a fairly simple first step is to detect collusion using statistical models for every auction that takes place (Porter and Zona 1993; Bajari and Ye 2003). To our knowledge, there is no quantitative evidence on different policies to combat collusion in the context of the construction sector in low income countries.

Higher transparency in the construction sector has been advocated as one way to combat collusion. An example for this is the Construction Sector Transparency Initiative (CoST), funded by the German Agency for International Cooperation, the United Kingdom's Department for International Development, and the World Bank which has been piloted in Tanzania, Zambia, Malawi, Vietnam, the Philippines, Ethiopia and the United Kingdom (Construction Sector Transparency Initiative 2011). Building up databases of unit costs of comparable activities will certainly assist governments in ensuring that they are not overpaying. However, there are trade-offs between publication of estimated costs and collusion. While the publishing cost estimates reduced average bids and left the size of the winning bid unchanged in auctions in Oklahoma, evidence from an Eastern European country showed that it led to bids almost exactly tracing the estimated costs suggesting that higher transparency helped companies collude (Silva et al. 2008; World Bank 2011a).

Third, this paper finds that the time it takes to enforce a contract is significantly correlated with costs. One interpretation of this finding is that the time it takes to enforce a contract reflects the strength of legal institutions in a country. If relational contracts allow the buyer to efficiently contract when courts are weak, but road contracts are allocated via a one stage sealed bid auction independent of the strength of the court system, governments in countries with weak law enforcement pay higher prices. Banerjee and Duflo (2000) argue that reputation is an important determinant of contracting outcomes for firms in the Indian software industry. Johnson et al. (2002) find that when courts are weak, firms which purchase customized products state that they would prefer to

[20]Data and analysis on market structure are scattered, for example see Lan (2010) for China and **?** for Nigeria; (Ofori 2007) underlines that in addition to the inadequate knowledge of the market structure of the local construction industry in developing countries, little attention has been given to the contribution of the informal sector to construction.

[21]See Hüschelrath et al. (2010) for a study on the road surfacing cartel in Switzerland, as well as a discussion of cases of cartels in Austria (Asphalt Mixing Plant), Netherlands (Bitumen), Finland (Asphalt) and Sweden (Asphalt).

keep the contract with their existing supplier when offered a 10% lower price from a new supplier. This highlights another trade-off, between fostering competition and rewarding good behavior of firms. Findings from the initial pilots under the Construction Sector Transparency Initiative showed that cost overruns in the sample of 145 contracts amount to 58% in Ethiopia, 35% in Vietnam, 10% in the Philippines and 6% in the United Kingdom, suggesting that hold up problems are of a significant magnitude. If construction firms could be compensated for good behavior by awarding future contracts to them, this could reduce hold-up problems, but decreases competition. One step towards increasing reputational concerns of firms is the World Bank Integrity Vice Presidency's debarment of 405 companies, non-governmental organizations and individuals[22]. These entities are listed on the website of the World Bank, including on which grounds they were debarred and the duration of ineligibility, thereby lowering their payoff from defecting.

This implies that there is scope for research into how companies which are honest and deliver efficiently could be rewarded positively, while not sacrificing competition. Krasnokutskaya and Seim (2011) evaluate the effects of a bid preference programs for small firms bidding for highway projects in California and find that the preference program significantly affects firms decisions to submit bids, and raises project costs between 1.5-2.3% once endogenous entry to bid is taken into account. To reduce time overruns (amounting to 130% in Ethiopia, 106% in Tanzania and 97% in Malawi (Construction Sector Transparency Initiative 2011)), Lewis and Bajari (2011) suggest score based auctions which are designed to internalize the costs of time overruns to construction sector firms.

Fifth, this paper was agnostic about the costs of inputs into production, such as equipment, raw materials, as well as human resources. Information on input prices would allow a better understanding of which part of the premium experienced in conflict and corrupt countries is due to higher input prices, and which part is due to rents obtained by firms undertaking the road work activities. Cartels do not only take place on the construction firm side, but also on the input side. For example, Hüschelrath et al. (2013) finds that cement prices dropped by 25% higher following the break-up of the German cement cartel. The construction sector PPP of the International Comparison Project 2011 has collected detailed information on a range of comparable input prices, which could be used as a first step to explore differences in unit costs across countries[23].

Finally, this paper and the main discussion was centered on transport infrastructure. A better understanding of unit costs of construction of other types of projects, for example, residential and commercial housing, is another avenue for further research. Advances in the methodology to measure unit costs are a prerequisite to understand differences in costs, so efforts should focus both on measurement as well as the analysis.

[22]As of 25 March 2013, list available under www.worldbank.org/integrity.
[23]To our knowledge, the data will be released in June 2013.

7 Conclusion

This paper presented a first systematic analysis of drivers of unit costs across countries. Our analysis yielded five main findings. First, we showed that there is a large dispersion in unit costs across countries for comparable road work activities. For example, the difference between countries of an asphalt overlay of 40 to 59 mm amounts to a factor of three to four. Second, we found that after accounting for environmental drivers of costs such as terrain ruggedness and proximity to markets, residual unit costs are significantly higher in fragile countries. Countries which are in conflict have about 30% higher unit costs. This result is robust across a range of measures of conflict and political instability. Third, we also find evidence that costs are higher in countries with higher levels of corruption. Countries with corruption levels as measured by the World Governance Indicators above the median in the sample have about 12% higher costs. Given that corruption and collusive practices might be even higher for projects undertaken directly by governments without the need to respect procurement procedures of the World Bank, the higher costs in corrupt environments are potentially a lower bound of the estimate. Fourth, the premium charged by firms in conflict and corrupt countries remains when we control for the government's public investment capacity and the business environment. Finally, we found that higher unit costs are significantly associated with lower levels of infrastructure provision. Based on these findings, we laid out a research agenda.

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8 Appendix

8.1 Data Sources for Additional Variables

8.1.1 Exchange Rate and Consumer Price Index

As the database does not contain consumer price indices and exchange rates after 2004, we recalculate all conversions using the official exchange rate (LCU per US$, period average) and the consumer price index from the World Development Indicators 2012. Projects denominated in currencies other than US$ were first deflated or inflated to the reference year 2000, and then converted into US$. Projects denominated in US$ were deflated to the reference year 2000 using the consumer price index of the United States. The costs are very similar to the ones provided in the database, with 93% (91%) of costs per km (square meter) lying within 2% of the original data provided[24].

8.1.2 Ruggedness

Our measure of ruggedness is taken from Nunn and Puga (2012) which in turn is based on Riley et al (1999). It represents the average ruggedness of a country and is measured in hundreds of meters of elevation difference for grid points about 926 meters apart. The lowest level of ruggedness is in Mauritania with an index of 0.115, and the highest is Bhutan, with an index of 6.740.

8.1.3 Rainfall

Our measure for rainfall is taken from Dell et al. (2012) and is defined as population weighted country level precipitation in 100s millimeters.

8.1.4 Basic Socio-economic Data

For the total population, total surface area, and GDP per capita for each country we use the World Development Indicators.

8.1.5 Public Sector Management Capacity

To measure the capacity of the public sector to execute projects we use the Public Investment Management Index (PIMI) collected by Dabla-Norris et al. (2011). The Public Investment Management Index is measured on a scale from 0 to 4.

8.1.6 The Business Environment

To measure the business environment of the country, we use data from the Doing Business Indicators in 2007 and measure costs in terms of time the number it takes to enforce a contract. We use 2007 because this is the first year for which we have complete coverage.

[24]Azerbeijan, Ghana and Venezuela devalued their currencies since 2000, so for these countries we use the unit cost data provided in the database.

Tables 11 shows the descriptive statistics of the control variables. Some variables are not available for the year of the construction project. We therefore distinguish between the following cases: first, if the variable is only available at one point of time we assign the available value to the construction project; second, if the variable is available for at least two years we distinguish between the following three cases: (i) when the construction project took place before the year the variable becomes available, we use data from the first year of the variable; (ii) when the construction project took place after the last time the explanatory variable is recorded, we then use the value of the last available observation; (iii) if the construction project took place in a year for which there are data points both before and after, we linearly interpolate the explanatory variable.

Table 11: Descriptive Statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Cost per km (2000 US$)	261741.12	558093.15	50.57	7810495.02	3322
Estimate	0.44	0.5	0	1	3322
Contract	0.27	0.44	0	1	3322
Actual	0.28	0.45	0	1	3322
International Bid	0.63	0.48	0	1	1471
Proc info missing	0.56	0.5	0	1	3322
Flat	0.38	0.49	0	1	1587
Hilly	0.09	0.29	0	1	1587
Mountainous	0.27	0.44	0	1	1587
Rolling	0.26	0.44	0	1	1587
Missing: Terrain	0.52	0.5	0	1	3322
East Asia & Pacific	0.21	0.41	0	1	3322
Europe & Central Asia	0.09	0.28	0	1	3322
Latin America & Caribbean	0.24	0.42	0	1	3322
Middle East & North Africa	0.03	0.17	0	1	3322
South Asia	0.14	0.35	0	1	3322
Sub-Saharan Africa	0.29	0.46	0	1	3322
Length > than 50 km	0.37	0.48	0	1	2452
Missing: Length	0.26	0.44	0	1	3322
Log Ruggedness	4.46	0.92	2.44	6.51	3322
Log of Rainfall	2.43	0.5	0.36	3.62	3319
Missing: Rainfall	0	0.03	0	1	3322
Log dist to coast	-1.45	1.21	-5.85	0.79	3322
Log of Surface Area	6.17	1.65	0.62	9.75	3322
Population Density	1.43	2	0.02	9.76	3322
Log of GDP per capita	6.69	1.2	0	9.07	3322
Missing: Log of GPD per capita	0	0.06	0	1	3322
Log of GDP pc (1985)	6.39	1.17	4.76	8.72	2985
Missing: Log of GPD pc (1985)	0.1	0.3	0	1	3322
ACD Conflict	0.25	0.43	0	1	3322
ACD Post-Conflict	0.12	0.32	0	1	3322
WGI Instability	0.56	0.63	-1.26	2.21	3322
TI Corruption	3.89	0.61	1.68	5.52	3314
Missing: TI Corruption	0	0.05	0	1	3322
WGI Corruption	0.48	0.46	-1.45	1.6	3322
WGI Corruption > Median	0.51	0.5	0	1	3322
Public Investment Management Index	1.92	0.6	0.27	3.53	2113
Missing: Public Investment Management Index	0.36	0.48	0	1	3322
Log of DB Start Business	3.64	0.62	1.79	5.31	3322
Log of DB Construction Permit	5.31	0.52	0	6.51	3322
Log of DB Register Property	3.98	1.16	0.69	6.53	3322
Log of DB Import+Export	4.08	0.42	2.89	5.19	3322
Log of DB Enforce Contract	5.39	2.2	0	6.89	3322

8.2 Tables and Figures

Table 12: Preservation Works

Work Class	Work Type	Predominant Work Activity
Routine	Routine Maintenance	Routine Maintenance Earth Road Routine Maintenance Gravel Road Routine Maintenance Block 2L Highway Routine Maintenance Bituminous 2L Highway Routine Maintenance Concrete 2L Highway Routine Maintenance Bituminous > 2L Highway Routine Maintenance Concrete > 2L Highway Routine Maintenance Bituminous Expressway Routine Maintenance Concrete Expressway
Periodic	Grading	Light Grading Heavy Grading
	Gravel Resurfacing	Regravelling
	Concrete Pavement Preventive Treatment	Concrete Pavement Preventive Treatment
	Bituminous Pavement Preventive Treatment	Fog Seal Rejuvenation
	Unsealed Preventive Treatment	Unsealed Preventive Treatment
	Surface Treatment Resurfacing	Slurry Seal or Cape Seal Single Surface Treatment Double Surface Treatment Triple Surface Treatment
	Asphalt Mix Resurfacing	Asphalt Overlay < 40 mm Asphalt Overlay 40 to 59 mm
Rehabilitation	Strengthening	Asphalt Overlay 60 to 79 mm Asphalt Overlay 80 to 99 mm Asphalt Overlay > 99 mm Mill and Replace Bonded Concrete Overlay Unbounded Concrete Overlay
	Concrete Pavement Restoration	Concrete Slab Replacement Concrete Slab Repair Concrete Diamond Grinding
	Reconstruction	Reconstruction Earth Reconstruction Gravel Reconstruction Block Reconstruction Bituminous Reconstruction Concrete

Table 13: Development Works

Work Class	Work Type	Predominant Work Activity
Improvement	Partial Widening	Partial Widening to Gravel 2L Partial Widening to Block 2L Partial Widening to Bituminous 2L Partial Widening to Concrete 2L
	Partial Widening and Reconstruction	Partial Widening and Reconstruction to Gravel 2L Partial Widening and Reconstruction to Block 2L Partial Widening and Reconstruction to Bituminous 2L Partial Widening and Reconstruction to Concrete 2L
	Widening	Widening Adding Bituminous 1L Widening Adding Bituminous 2L Widening Adding Bituminous 4L Widening Adding Concrete 1L Widening Adding Concrete 2L Widening Adding Concrete 4L
	Widening and Reconstruction	Widening and Reconstruction Adding Bituminous 1L Widening and Reconstruction Adding Bituminous 2L Widening and Reconstruction Adding Bituminous 4L Widening and Reconstruction Adding Concrete 1L Widening and Reconstruction Adding Concrete 2L Widening and Reconstruction Adding Concrete 4L
	Upgrading	Upgrading to Earth 2L Upgrading to Gravel 2L Upgrading to Block 2L Upgrading to Bituminous 2L Upgrading to Concrete 2L
New Construction	New 1L Road	New Earth 1L Road New Gravel 1L Road New Block 1L Road New Bituminous 1L Road New Concrete 1L Road
	New 2L Highway	New Earth 2L Highway New Gravel 2L Highway New Block 2L Highway New Bituminous 2L Highway New Concrete 2L Highway
	New 4L Highway	New Bituminous 4L Highway New Concrete 4L Highway
	New 6L Highway	New Bituminous 6L Highway New Concrete 6L Highway
	New 4L Expressway	New Bituminous 4L Expressway New Concrete 4L Expressway
	New 6L Expressway	New Bituminous 6L Expressway New Concrete 6L Expressway

Table 14: Cost per km for Different Work Types, by Work Category

Development	N	mean	p50	sd	min	max
New 6L Expressway	1	5,571,488	5,571,488	.	5,571,488	5,571,488
New 4L Expressway	65	2,838,562	2,495,592	1,474,420	937,499	7,810,495
New 4L Highway	11	2,195,810	2,213,333	1,159,299	660,242	4,561,035
New 6L Highway	2	1,990,155	1,990,155	991,449	1,289,094	2,691,215
Widening and Reconstruction	108	874,209	776,071	752,950	178,494	6,532,523
Widening	138	842,697	776,071	742,325	8,751	5,785,612
New 2L Highway	68	750,396	696,537	399,828	22,403	1,985,876
Partial Widening and Reconstruct	117	261,380	252,202	129,635	8,219	682,508
Upgrading	360	250,472	218,863	171,322	3,551	940,837
Partial Widening	12	137,773	148,321	29,027	67,299	168,278
New 1L Road	7	91,788	81,244	36,153	58,151	167,702
Total	889	678,283	358,293	930,798	3,551	7,810,495

Preservation	N	mean	p50	sd	min	max
Concrete Pavement Restoration	4	539,348	650,623	321,650	68,558	787,587
Reconstruction	745	220,287	169,668	209,577	1,973	2,615,657
Strengthening	422	139,371	120,799	75,097	27,473	553,857
Asphalt Mix Resurfacing	458	64,551	60,356	29,538	12,350	211,000
Surface Treatment Resurfacing	230	25,090	18,767	23,520	3,409	176,682
Gravel Resurfacing	275	18,169	13,198	15,765	1,872	112,950
Bituminous Pavement Preventive Treatment	47	7,355	5,534	6,190	1,147	30,653
Unsealed Preventive Treatment	101	4,347	4,385	1,319	2,009	8,402
Routine Maintenance	119	2,144	1,897	1,383	277	8,685
Grading	23	515	151	771	51	2,542
Total	2,424	109,930	67,561	149,738	51	2,615,657

Table 15: Cost per km for Development Works, by Work Activity

Development work activity	N	mean	p50	sd	min	max
New Bituminous 6L Expressway	1	5,571,488	5,571,488	.	5,571,488	5,571,488
Widening Adding Bituminous 4L	2	4,643,333	4,643,333	1,615,426	3,501,055	5,785,612
New Bituminous 4L Expressway	65	2,838,562	2,495,592	1,474,420	937,499	7,810,495
New Concrete 4L Highway	1	2,213,333	2,213,333	.	2,213,333	2,213,333
New Bituminous 4L Highway	10	2,194,058	2,177,899	1,221,993	660,242	4,561,035
New Bituminous 6L Highway	2	1,990,155	1,990,155	991,449	1,289,094	2,691,215
Adding Bituminous 4L	8	1,855,587	1,832,513	186,580	1,568,359	2,088,700
Widening Adding Concrete 1L	2	1,641,940	1,641,940	21,358	1,626,837	1,657,043
New Block 2L Highway	1	1,264,231	1,264,231	.	1,264,231	1,264,231
Widening and Reconstruction Adding Bituminous 2L	61	1,085,967	989,080	790,232	241,875	6,532,523
New Bituminous 2L Highway	43	828,245	764,706	378,909	224,882	1,985,876
Widening Adding Bituminous 2L	120	812,194	611,882	573,139	163,469	3,497,181
Widening Adding Concrete 2L	2	626,842	626,842	163,489	511,238	742,446
New Concrete 2L Highway	4	467,990	460,773	61,948	408,051	542,364
Widening and Reconstruction Adding Bituminous 1L	36	304,665	257,007	126,310	178,494	616,324
Upgrading to Concrete 2L	13	302,035	356,189	149,254	55,523	465,583
Upgrading to Bituminous 2L	283	276,508	241,148	166,059	29,897	940,837
Partial Widening and Reconstruction to Bituminous 2L	114	267,427	259,679	125,657	28,052	682,508
Widening Adding Bituminous 1L	7	265,241	260,115	287,751	8,751	702,651
Upgrading to Block 2L	13	168,742	165,477	66,341	42,710	325,644
Partial Widening to Bituminous 2L	12	137,773	148,321	29,027	67,299	168,278
New Gravel 2L Highway	5	124,079	111,650	103,110	22,403	232,864
New Gravel 1L Road	2	112,926	112,926	77,464	58,151	167,702
New Bituminous 1L Road	1	99,800	99,800	.	99,800	99,800
New Earth 1L Road	4	79,215	76,864	9,152	71,800	91,335
Upgrading to Gravel 2L	32	58,825	52,491	32,724	15,940	161,949
Partial Widening and Reconstruction to Gravel 2L	3	31,614	13,288	36,219	8,219	73,334
Upgrading to Earth 2L	6	12,683	13,432	6,593	3,551	20,377
Total	853	682,288	348,307	947,126	3,551	7,810,495

Table 16: Cost per km for Preservation Works, by Work Activity

Preservation work activity	N	mean	p50	sd	min	max
Concrete Slab Replacement	3	696,277	684,879	86,177	616,367	787,587
Reconstruction Bituminous	595	247,848	196,167	216,894	20,165	2,615,657
Reconstruction Concrete	31	236,432	222,319	119,577	50,890	487,139
Asphalt Overlay > 99 mm	91	183,925	167,059	76,022	56,275	478,158
Asphalt Overlay 80 to 99 mm	140	136,484	118,752	70,626	38,583	553,857
Mill and Replace	38	130,524	105,147	76,856	48,892	353,720
Asphalt Overlay 60 to 79 mm	54	91,572	87,437	30,920	27,473	180,761
Asphalt Overlay 40 to 59 mm	298	71,637	69,905	27,668	20,073	211,000
Reconstruction Block	2	51,816	51,816	37,039	25,626	78,007
Reconstruction Gravel	86	44,158	39,356	28,482	5,086	131,778
Asphalt Overlay < 40 mm	81	41,963	38,078	17,396	12,350	95,148
Double Surface Treatment	71	31,918	29,446	21,376	10,246	176,682
Single Surface Treatment	61	21,431	18,254	14,773	5,295	106,457
Double Surface Treatment	2	21,351	21,351	11,604	13,146	29,556
Reconstruction Earth	7	20,834	17,724	17,029	1,973	56,561
Regravelling	233	16,420	12,242	13,397	1,872	65,038
Slurry Seal or Cape Seal	48	13,917	10,575	9,230	3,409	35,805
Fog Seal	9	8,313	6,915	4,612	2,805	15,783
Unsealed Preventive Treatment	99	4,277	4,343	1,236	2,009	8,402
Routine Maintenance Block 2L Highway	2	2,728	2,728	1,736	1,500	3,956
Routine Maintenance Bituminous > 2L Highway	2	2,241	2,241	1,797	970	3,512
Routine Maintenance Bituminous 2L Highway	71	2,232	1,964	1,232	332	5,580
Routine Maintenance Concrete 2L Highway	1	1,483	1,483	.	1,483	1,483
Routine Maintenance Earth Road	2	1,185	1,185	1,216	325	2,045
Heavy Grading	9	1,144	591	948	323	2,542
Routine Maintenance Gravel Road	17	1,110	1,229	616	277	2,042
Light Grading	14	111	110	47	51	205
Total	2,067	116,228	71,896	156,977	51	2,615,657

Table 17: List of Countries (1)

	1984-1990	1991-1995	1995-2000	2001-2005	2005-2008	Total
Afghanistan	0	0	0	12	0	12
Albania	0	5	31	20	3	59
Algeria	0	3	3	0	0	6
Angola	0	0	0	8	0	8
Argentina	0	64	17	15	19	115
Armenia	0	3	48	0	0	51
Azerbaijan	0	0	0	2	0	2
Bangladesh	0	49	110	29	0	188
Belize	0	0	0	3	0	3
Benin	0	0	0	2	0	2
Bhutan	0	0	0	4	3	7
Bolivia	2	4	20	11	0	37
Bosnia and Herzegovin	0	0	0	1	7	8
Botswana	0	1	0	0	4	5
Brazil	8	42	33	32	33	148
Bulgaria	0	0	0	0	6	6
Burkina Faso	0	0	0	24	2	26
Burundi	0	0	0	3	2	5
Cambodia	0	0	0	11	4	15
Cameroon	0	4	12	13	0	29
Cape Verde	0	7	0	8	0	15
Chad	0	2	0	3	0	5
Chile	9	12	11	0	7	39
China	1	25	37	61	5	129
Colombia	0	13	0	0	0	13
Comoros	0	0	2	0	0	2
Congo	0	0	0	0	1	1
Costa Rica	0	0	6	0	0	6
Dem. Rep. Congo	0	0	0	16	1	17
Djibouti	0	0	5	6	0	11
Dominican Republic	1	4	36	2	0	43
Ecuador	0	1	0	12	0	13
El Salvador	0	0	4	0	0	4
Ethiopia	0	0	38	33	3	74
Fiji	0	0	1	0	0	1
Georgia	0	0	0	3	3	6
Ghana	2	29	217	38	1	287
Guatemala	0	3	0	0	0	3
Guinea	0	1	0	9	0	10
Haiti	0	0	1	7	0	8
Honduras	0	12	6	0	14	32
India	13	7	84	63	11	178
Indonesia	0	9	8	21	1	39
Iran	0	0	0	0	1	1
Jamaica	0	1	0	0	0	1
Jordan	0	4	4	0	0	8
Kazakhstan	0	0	17	7	0	24
Kenya	0	1	0	34	6	41
Kyrgyz Republic	0	2	5	7	0	14
Lao PDR	3	10	35	46	6	100

Table 18: List of Countries (cont.)

	1984-1990	1991-1995	1995-2000	2001-2005	2005-2008	Total
Latvia	0	0	6	0	0	6
Lebanon	0	14	9	25	0	48
Lesotho	0	0	4	3	0	7
Lithuania	0	0	5	0	0	5
Macedonia	0	0	2	13	3	18
Madagascar	0	1	1	8	0	10
Malawi	0	3	0	15	0	18
Malaysia	0	1	0	0	0	1
Mali	0	2	3	2	1	8
Mauritania	0	0	0	1	0	1
Mauritius	0	2	0	0	0	2
Mexico	3	8	49	2	0	62
Moldova	0	0	0	0	2	2
Mongolia	0	0	1	7	0	8
Morocco	0	2	0	2	0	4
Mozambique	0	0	0	21	3	24
Namibia	0	0	0	3	0	3
Nepal	0	8	7	7	7	29
Nicaragua	0	8	11	20	0	39
Niger	0	0	3	6	1	10
Nigeria	0	11	22	11	9	53
Pakistan	0	0	22	34	0	56
Panama	0	0	12	33	0	45
Papua New Guinea	0	4	1	29	0	34
Paraguay	0	5	5	13	0	23
Peru	0	14	8	5	0	27
Philippines	5	26	61	52	10	154
Romania	0	0	1	3	0	4
Russia	0	44	17	0	0	61
Rwanda	0	0	0	1	5	6
Samoa	0	0	1	0	0	1
Senegal	0	0	3	14	0	17
Serbia	0	1	0	0	0	1
Sierra Leone	0	6	0	7	0	13
South Africa	0	0	0	3	0	3
Sri Lanka	0	0	4	0	0	4
Swaziland	0	0	0	1	0	1
Tanzania	0	2	25	8	1	36
Thailand	0	29	116	25	0	170
Tunisia	0	6	2	4	0	12
Turkey	0	0	2	24	0	26
Uganda	0	11	173	18	0	202
Uruguay	0	11	61	0	0	72
Venezuela	0	1	47	1	0	49
Vietnam	0	3	14	18	7	42
West Bank and Gaza	0	0	3	0	0	3
Yemen	1	4	3	2	0	10
Zambia	0	16	0	15	0	31
Zimbabwe	0	4	0	0	0	4
Total	48	565	1,495	1,022	192	3,322

Table 19: Unit Costs per Square Meter of Asphalt Overlays 40 to 59 mm

Country	Cost per Square Meter	Number	Year	Country	Cost per Square Meter	Number	Year
Work activities undertaken between 1996-1998							
Dominican Republic	4.8	1	1997	Argentina	10.3	1	1996
Lithuania	6.1	1	1996	Cameroon	10.5	4	1997
Ghana	6.1	5	1998	India	10.5	3	1997
Lithuania	6.8	1	1998	Bangladesh	10.8	26	1998
Indonesia	6.9	1	1996	Vietnam	11.4	2	1998
Mexico	7.0	1	1997	Bangladesh	11.5	1	1997
Ghana	7.5	1	1996	Panama	11.5	1	1997
Armenia	8.3	1	1997	Nigeria	13.0	1	1997
Brazil	8.6	2	1996	Pakistan	14.4	1	1997
Bolivia	9.2	1	1997	El Salvador	14.6	1	1998
Argentina	9.6	1	1997	Tanzania	14.9	1	1996
Brazil	10.2	1	1998				

Notes: Costs per square meter of asphalt overlays 40 to 59 mm; all costs are in 2000 US$; number denotes the number of contracts in a given country over which a simple average is taken.

Table 20: Differences in Unit Costs across different Work Types

	eq1 (1)	eq2 (2)
Preservation Works		
Routine Maintenance	-4.289*** (0.143)	-4.256*** (0.174)
Grading	-6.396*** (0.352)	-6.305*** (0.374)
Gravel Resurfacing	-2.275*** (0.117)	-2.207*** (0.159)
Bituminous Pavement Preventive Treatment	-3.076*** (0.134)	-2.989*** (0.18)
Unsealed Preventive Treatment	-3.375*** (0.179)	-3.441*** (0.193)
Surface Treatment Resurfacing	-1.981*** (0.135)	-1.917*** (0.185)
Asphalt Mix Resurfacing	-.848*** (0.092)	-.862*** (0.143)
Strengthening	-.117 (0.085)	-.174 (0.15)
Concrete Pavement Restoration	1.000 (0.629)	1.045* (0.553)
Reconstruction	0.073 (0.102)	0.029 (0.157)
Development Works		
Partial Widening and Reconstruction	0.258 (0.224)	0.405*** (0.151)
Widening	1.410*** (0.171)	1.415*** (0.21)
Widening and Reconstruction	1.539*** (0.142)	1.485*** (0.188)
Upgrading	0.271** (0.118)	0.229 (0.162)
New 1L Road	-.349** (0.148)	-.027 (0.191)
New 2L Highway	1.529*** (0.199)	1.450*** (0.245)
New 2L Highway	1.529*** (0.199)	1.450*** (0.245)
New 4L Highway	2.542*** (0.297)	2.502*** (0.305)
New 6L Highway	2.464*** (0.097)	2.405*** (0.162)
New 4L Expressway	2.824*** (0.072)	2.735*** (0.156)
New 6L Expressway	3.682*** (0.127)	3.406*** (0.224)
Obs.	3322	3322
R^2	0.83	0.841

Notes: Omitted category is partial widening; column (1) includes year dummies and contract characteristics included in all models; column (2) also includes country characteristics; standard errors brackets, clustered at the country level; *, **, *** denote significance at 10%, 5% and 1% levels.

Table 21: Baseline Results

	BASEI	BASEII	BASEIII
	(1)	(2)	(3)
Estimate	-.024 (0.059)	-.022 (0.058)	-.020 (0.058)
Contract	-.080 (0.054)	-.085 (0.055)	-.078 (0.054)
Geography			
Log Ruggedness	0.155*** (0.035)	0.151*** (0.037)	0.157*** (0.036)
Log of Rainfall	-.028 (0.07)	-.041 (0.071)	-.036 (0.071)
Log dist to coast	-.023 (0.051)	-.040 (0.054)	-.020 (0.051)
Population Density	0.105*** (0.019)	0.103*** (0.02)	0.107*** (0.02)
Log of Surface Area	0.081*** (0.022)	0.092*** (0.024)	0.081*** (0.022)
Length > than 50 km	-.093** (0.038)	-.105*** (0.039)	-.096** (0.039)
Log of GDP per capita		-.056 (0.038)	
Log of GDP pc (1985)			-.005 (0.046)
Pilot Country	-.095 (0.074)	-.096 (0.079)	-.099 (0.075)
East Asia & Pacific	-.490*** (0.096)	-.449*** (0.107)	-.486*** (0.103)
Europe & Central Asia	-.133 (0.09)	-.060 (0.103)	-.076 (0.105)
Latin America & Caribbean	-.175* (0.098)	-.066 (0.127)	-.167 (0.141)
Middle East & North Africa	-.438*** (0.106)	-.340** (0.141)	-.372*** (0.113)
South Asia	-.445*** (0.114)	-.431*** (0.121)	-.455*** (0.115)
Obs.	3322	3322	3322
R^2	0.896	0.896	0.896

Notes: Dependent variable is the log of cost per km; all models control for work activity fixed effects, year fixed effects, an interaction between work type and 5-year period fixed effects; base categories are actual costs; robust standard errors in parentheses, clustered at the country; *, **, *** denote significance at 10%, 5% and 1% levels.