DISCUSSION PAPER SERIES

No. 7662

A FRAMEWORK FOR CROSS-COUNTRY COMPARISONS OF PUBLIC INFRASTRUCTURE CONSTRAINTS ON FIRM GROWTH

Wendy Carlin, Mark E. Schaffer
and Paul Seabright

DEVELOPMENT ECONOMICS and PUBLIC POLICY

Centre for Economic Policy Research

www.cepr.org

Available online at: **www.cepr.org/pubs/dps/DP7662.asp**

ISSN 0265-8003

A FRAMEWORK FOR CROSS-COUNTRY COMPARISONS OF PUBLIC INFRASTRUCTURE CONSTRAINTS ON FIRM GROWTH

Wendy Carlin, University College London and CEPR
Mark E. Schaffer, Heriot-Watt University and CEPR
Paul Seabright, Toulouse School of Economics and CEPR

Discussion Paper No. 7662
January 2010

Centre for Economic Policy Research
53–56 Gt Sutton St, London EC1V 0DG, UK
Tel: (44 20) 7183 8801, Fax: (44 20) 7183 8820
Email: cepr@cepr.org, Website: www.cepr.org

CEPR Discussion Paper No. 7662

January 2010

ABSTRACT

A Framework for Cross-Country Comparisons of Public Infrastructure Constraints on Firm Growth

How should a policy-maker prioritize interventions to improve the public infrastructure with which firms operate and how large are the benefits from doing so likely to be? To address these questions we use survey data on the obstacles arising from poor quality public inputs that managers face in running their firms. Our conceptual framework centres on the public input character of physical infrastructure and institutions, and uses an O-ring production function to model the impact of poor quality infrastructure on output. Using survey data from over 72,000 firms in 95 countries, we verify the consistency of the within- and cross-country variation in reported constraints with predictions of the model. We use the framework to construct estimates of the impact on output and productivity of improvements in the quality of public inputs and how these differ between rich and poor countries. We show how a policy-maker can use the country-level data and the benchmarks estimated from the cross-country data to prioritize public infrastructure investment in their country. Our results indicate that priorities vary widely among countries and suggest a degree of caution about donor policies tying development assistance to generic improvements in the business environment. The results also suggest that the benefits arising directly from such improvements are likely to be modest relative to the scale of impact implied by aggregate-level studies of the role of institutions in economic development.

JEL Classification: H41, O12, O16 and O57
Keywords: constraints on growth, finance, infrastructure, institutions, O-ring production function, public infrastructure, public inputs and subjective data

Wendy Carlin
Department of Economics
University College London
Gower Street
London
WC1E 6BT

Email: w.carlin@ucl.ac.uk

For further Discussion Papers by this author see:
www.cepr.org/pubs/new-dps/dplist.asp?authorid=115115

Mark E Schaffer
Centre for Economic Reform and Transformation, Dept of Economics
Heriot-Watt University
Riccarton
Edinburgh
EH14 4AS

Email: m.e.schaffer@hw.ac.uk

For further Discussion Papers by this author see:
www.cepr.org/pubs/new-dps/dplist.asp?authorid=110682

Paul Seabright
Institut d'Economie Industrielle
Université de Toulouse-1
Manufacture de Tabacs
21, Allée de Brienne
31000 Toulouse
FRANCE

Email: seabrigh@cict.fr

For further Discussion Papers by this author see:
www.cepr.org/pubs/new-dps/dplist.asp?authorid=108588

This Paper is produced as part of the CEPR project 'SCience, Innovation, FIrms and markets in a GLObalized World' funded by the European Commission under its Seventh Framework Programme for Research (Collaborative Project).

Submitted 16 January 2010

1. Introduction

How should a policy-maker prioritize interventions to improve the public infrastructure environment in which firms operate? We propose an approach to this problem that makes use of a large firm-level data set registering managers' rankings of the importance of external constraints for the operation and growth of their firm. Our approach allows us to tackle what have been up to now the two greatest difficulties in investigating empirically the nature of institutional constraints on firm growth. The first is that these constraints vary from country to country in their impact on firms. The second is that there are many different relevant aspects of the infrastructure environment, but it is difficult to distinguish their various impacts on firm performance because they are significantly correlated.

The approach we outline consists of asking managers in over 72,000 firms spread over 95 countries not simply to describe the state of infrastructure in their country, but more specifically to evaluate the impact of each of several dimensions of the infrastructure on the output of their businesses. Provided these answers are collected and interpreted with care, we can use them as the basis for a direct measure of the potential benefits to be gained from improvements in the state of each particular component of the infrastructure. This contrasts with the approach that has generally been used to measure the impact of institutional constraints on firm performance, which is to use such measures in cross-country regressions of the determinants of growth, and to interpret the regression coefficient on infrastructure as the appropriate measure of the benefits of infrastructure improvements. Because this point is central to the paper it is worth explaining the difference in these approaches in some detail.

The standard approach to the question of how the productivity and growth of firms is affected by the quality of their institutional environment is to attempt to uncover an "average treatment effect" of institutions on growth using cross-country regression analysis where a measure of performance is regressed on indicators of institutions and other controls. Recent studies have sought to find good instrumental variables for the institutional environment to mimic a quasi-experimental setting, corresponding to a thought experiment in which some exogenous shock leads to an improvement in institutional quality at the sample mean. For instance, Hall & Jones (1999) regress output per worker on a proxy measure of "social infrastructure" constructed from

indicators of government antidiversion policies and openness to international trade; as instruments for this endogenous measure they use distance from the equator and the extent of West European languages. Acemoglu et al. (2000) regress GDP per capita on two alternative measures, one an index of protection against expropriation and the other an indicator of constraints on the executive; as instruments they use the mortality of the original colonial settlers. Both studies find apparently large effects of institutions, on productivity and output respectively.

There are three major problems with using regression coefficients estimated in this way as a measure of the benefits to be expected from improving infrastructure. The first is that it is hard to believe that variables such as distance from the equator and settler mortality are truly exogenous - that is, correlated with output or GDP *only* through their effect on the quality of institutions. In particular, to be valid instruments they need to be uncorrelated with any omitted variable that properly belongs in the main regression. Exogeneity is testable via overidentification tests, but there are weaknesses to these tests. The equation must be overidentified, and the test will not have any power if the instruments all identify the same wrong coefficient. These issues are mostly well known if not always well understood.

The second problem, which has been much less discussed in the literature, is that it is quite unclear how to interpret the proposed measures of institutions. There are many possible aspects of institutional quality that might affect economic development, and many of these aspects are correlated. Countries well endowed on one measure are likely to be well endowed on many of the others, meaning there are insufficient degrees of freedom to test for one measure against another (this is sometimes known as "the curse of dimensionality").[1] Instead, most studies in this literature test for the importance of one aspect of the institutional environment against the null hypothesis that there is *no* systematic influence on productivity other than some basic factor endowments. However, this is not interesting as a null hypothesis, and its statistical rejection in no way implies that the particular proposed institutional measure in fact determines development, rather than happening to be correlated with whatever it is that does.

[1] Horowitz (2004) illustrates the curse of dimensionality in the context of the evaluation of the right to carry gun laws.

The third problem for this approach would be serious even if satisfactory solutions could be found to the first two. A policy-maker seeks guidance on which dimension(s) of the institutional environment to prioritize for her specific country – not for the average country.[2] In the case of randomized control trials (RCTs) of drugs in medicine and the applications in economics where randomized experiments are used to evaluate labor market and welfare interventions, it is assumed that the population of the treated and the untreated (individuals or households) share common characteristics (e.g. physiological or behavioural ones) that determine their responses to the treatment. In this case, an average treatment effect from a clinical medical trial yields insights that can be applied to an average individual who falls ill. This is what is meant by saying that random assignment allows a policy relevant average treatment effect to be estimated because there are no *systematic* differences between the group receiving and the group not receiving the treatment. Whereas the "common physiology or household behaviour" hypothesis underlying the use of randomized trials in medicine or micro policy evaluation may be reasonable and there may be circumstances in which the efficacy of the treatment determined in the RCT can be used in a drug- or policy-prescription setting, the analogous hypothesis that countries with and without certain institutions otherwise share a common technology of development is implausible.

Hausmann, Rodrik and Velasco (2008) and Dixit (2007) point to the limited usefulness of the results of cross-country regression analyses in identifying country-specific priorities for policy and propose ways of undertaking policy-relevant growth diagnostics. Our approach is in the same spirit but we model bottlenecks differently because we wish to match the modelling directly with business environment survey data. The aim of this paper is to show that when they are correctly interpreted these data in fact yield intuitive and valuable insights.

The surveys (BEEPS, PICS, ICA) have a series of questions with the following wording: "Can you tell me how problematic are these different factors for the operation and growth of your business?" There are 4 allowable answers ranging from

[2] Deaton (2009) highlights the problems for inference of heterogeneity in both experimental and quasi-experimental settings. His examples include the impact of aid on development.

"No obstacle" to "Major obstacle".[3] It is tricky to translate this into a standard production function framework for a number of reasons. To begin with, it is an evaluation of an impact rather than a description of the quantity of infrastructure services supplied.

To see why this matters, consider what might happen if such questions were applied to internet access. A firm in a rich country might find that problems of internet access were a significant obstacle to the operation and growth of its business, because its business model depended on sophisticated internet access in real time to its customer base. A firm in a poor country might answer that there was no problem at all because it never used the internet. The poor country would score well on internet access problems and the rich country would score badly, and indeed these problems would be more of a constraint on business operation in the rich country. But it could not therefore be concluded that the state of the internet infrastructure was better in the poor than in the rich country. It is therefore important to develop a framework in which these answers can be interpreted as what they indeed appear to be, namely a direct measure of the cost to the firm of unreliable or poor quality public infrastructure rather than forcing them to appear as factor inputs in a standard production function. If we were to estimate in a regression framework the impact of internet access on firm productivity using these measures as a factor input (instead of, say, bandwidth or download speeds), we would find that problems with internet access were associated with higher productivity.

This example illustrates the difficulties faced when using the standard production function approach to capture the impact of public infrastructure on firm productivity using these answers: more productive firms report higher costs of poor provision. Rather than try to solve this fundamental endogeneity problem within the standard production function approach, we propose an alternative framework in which we model and estimate the variation in these valuations; in a nutshell, we move what was a right-hand side variable to the left-hand side.

[3] In some surveys, a fifth category, "very severe obstacle", is added.

Two other features of the data also need to be reflected in the framework. The first is that the same scaling is used for all inputs. This underlines the desirability of interpreting the answers in the common currency of costs of forgone profits or sales rather than in the different units of the various inputs. Secondly, the question as posed explicitly allows for the possibility that infrastructure may impose no constraint, via the answer “no obstacle”. We therefore want a framework that allows for “satiation” in this sense and that makes the answers comparable across types of public inputs for a single firm and comparable across firms and countries.

We do this by thinking of public infrastructure as an input whose reliability is uncertain, and using a probability metric for that reliability. A feature of infrastructure is a “major obstacle” when the public input is likely to fail often, and “no obstacle” corresponds to outcome when the public input is highly or 100% reliable. As we describe in more detail in section 3, we are able to determine a reasonable range of probabilities that correspond to the answer "major obstacle" by matching it with the answer to separate questions on the percentage of lost sales due to power and telecom outages. This then allows us to simulate the extent to which overall output may fall below what it would have been otherwise due to the combined impact of all the constraints faced by a firm. Comparing these results across countries gives us some sense of the comparative total costs faced by firms due to weaknesses in the public infrastructure.

The framework we use centres on the public input character of many external constraints. By public input, we mean that the infrastructure input may be rivalrous in consumption by firms but is non-excludable (Atkinson and Stiglitz, 1980). Examples of rivalrous public inputs are physical infrastructure, the legal system (courts), customs administration, and crime prevention. Non-rivalrous ones include the macroeconomic environment, the framework for delivering policy certainty, or for controlling bribes. The public input often has a zero price. For constraints that can be modelled as public inputs, the supply of this form of infrastructure (e.g., the legal system, customs regulation) is common to all firms in the country.

We formalize the probability metric using an O-ring production function (Kremer 1993). The idea is that each worker contributes an essential component to total output.

The contribution is successful if all the required infrastructure inputs are provided; the component fails because, for example, the electricity went out, or there was vandalism or theft, or customs clearance didn't come through in time. O-ring technology means that if any single component fails, the output of the firm is zero.

The O-ring model allows us to predict the way the "reported cost" of an external public input constraint varies with firm characteristics such as size, sector, exporter status, ownership and manager education (holding the availability of the public input constant). We verify using the survey data that variation in the reported cost across firms is consistent with the responses reflecting an O-ring reliability measure. Larger and higher-productivity firms generally report higher reported costs, and the variations in reported costs across different types of public inputs are plausibly correlated with the differing intensities with which different types of firms use these inputs. For example, construction firms report higher costs from problems with access to land and with corruption than do manufacturing firms, and exporters report higher costs associated with customs regulations than do non-exporters.

We also examine how consistent the country-level average reported cost measures from the manager perceptions data are with a well-established fact about economic development by taking the example of rural/urban differentials. Since urbanization increases with development, this suggests that in low GDP per capita countries the average reported cost of public input constraints will be higher in urban areas where growth is concentrated than in rural areas. This rural-urban differential in the reported cost should disappear as integration across the country takes place with development, and should therefore be absent in rich countries. The data conform to this prediction across a wide range of institutional dimensions of public infrastructure.

Having established that the within and cross-country data appear consistent with the proposed O-ring model, we assess the scope for using the average reported cost of the constraint as a framework for uncovering the main bottlenecks to growth at the country level. We do this by using the cross-country dimension of the dataset to create benchmark measures for a typical country at a given level of GDP per capita, which allows us to answer the following questions:

1. Do firms in country j generally report themselves as more constrained than firms in a typical country?

2. Do firms in country j report that constraint k is high – a priority – compared to other constraints in that country?

3. Do firms in country j report that constraint k is high compared to how firms in a typical country report it?

4. Do firms in country j report that constraint k is high compared to other constraints, vs. how firms in a typical country report constraint k vs. other constraints?

To illustrate how the answers to these questions can be used in a policy context, we present three case studies taking in each case two countries from a region: Brazil and Chile, Bangladesh and Pakistan, and Mozambique and Senegal. The messages about the main bottlenecks vary within and across regions. Among these six countries, macroeconomic stability (Brazil), electricity (Senegal, Bangladesh, Pakistan), transport (Senegal), and elements of the institutional infrastructure (access to land (Bangladesh), labor regulation (Brazil, Chile, Pakistan), tax administration (Brazil), corruption (Brazil, Bangladesh, Pakistan) and crime (Mozambique) emerge as of particular significance.

The structure of the paper is as follows. In the next section, we set out a simple model using an O-ring production function that provides for a public inputs interpretation of the infrastructure constraints on firms. In Section 3, we investigate the extent to which the firm-level data reporting manager perceptions are consistent with the proposed framework, to see whether the numbers make intuitive sense. First, we verify that the answers vary across firms in ways intuitively consistent with firm characteristics. Second, we use the example of rural-urban differentials to check for consistency between the data and a stylized fact about economic development. Third, we match the answers about constraint severity to answers about lost sales from power and telecoms outages, and simulate total output differences between countries associated with unreliable public inputs implied by this scaling. Section 4 addresses the question of how the data can be used in policy-making.

2. A Public Inputs Interpretation of Infrastructure Constraints on Firm Growth using an O-ring Production Function

We propose an approach to the measurement of institutional constraints that is non-parametric in the sense that it imposes no prior restriction on the values that such constraints may take in a given country, either absolutely or relatively to their values in other countries. The underlying idea is that public infrastructure should be considered as a kind of public good, which may or may not impede the efficient functioning of firms in an economy. The importance of those institutions for economic performance will then be measured by the assessment by firms of the impact of infrastructure reliability on their operations and growth.

To identify the current state of a type of public infrastructure as constraining economic development is to say that at given current market prices, economic agents cannot access as good a quality of infrastructure as they would like, and their inability to do so has a cost in terms of forgone output. For many of the public inputs we consider, the price is zero, i.e., even at a zero price, weaknesses in the supply of public infrastructure reduce firm performance.

We design a framework for assessing the extent of public infrastructure constraints on firm growth that is suited to the data on manager perceptions of the importance of a variety of business environment constraints for firm performance and growth. We want to be able to compare the benefits from improvement across a range of types of public infrastructure and we want a metric that will map into the managers' answers ranging from "constraint k is not a problem" to "constraint k is a major problem". A production function that meets these criteria incorporates the so-called O-ring technology of Kremer (1993).[4] Kremer combines the O-ring production function with heterogeneity in worker skills and assortative matching, and shows how these relate to stylized facts of economic development such as the very large income differentials between rich and poor countries. Kremer (pp. 560-1) discusses how O-ring technology can magnify the costs of bottlenecks caused by poor public inputs such as police protection, electricity supply, transport and communications services, etc. We

[4] O-ring technology was introduced in Kremer's 1993 paper in the context of the economics of development; a similar framework; Stinchcombe and Harris (1969) used a similar framework to look at very different question, the effectiveness of supervision in organizations.

use the O-ring production function in a new but related way: instead of using O-ring technology to capture the level of skill of a worker, we use it to capture the quality of public input provision. We assume that production uses a variable input that requires public infrastructure in order to successfully produce output. If the required infrastructure is not present, then the component fails and with O-ring technology, if a single component fails, output is zero.

2.1 The Model

The model is set up in the following way: i, j, and k index the firm, country and type of infrastructure respectively. The production function has one input, labor. There are also firm-specific and country-specific multiplicative technology parameters E_{ij} and A_j, respectively. A firm hires L_{ij} workers to produce its output; as a shorthand, we use the notation $n \equiv L_{ij}$. The quality and provision of infrastructure is captured by a parameter $0 < Q_{jk} \leq 1$. Q_{jk} captures the probability that infrastructure provision will (not) fail when used by a single worker, where $Q_{jk} = 1$ implies that infrastructure does not fail. The scale of use of the infrastructure input is given by the total number of workers.

We allow the frequency that the infrastructure is used by an individual worker to vary across infrastructure types k, firms i, and countries j . We refer to this as variation in the "relevance" of the type of infrastructure and it is captured by a parameter $\beta_{ijk} \geq 0$. It is a feature of the technology employed. The probability that the infrastructure provision does not fail in the course of use by a single worker is thus $Q_{jk}^{\beta_{ijk}}$ and the probability that the provision does not fail across all workers is $Q_{jk}^{\beta_{ijk} n}$. Thus the intensity with which the infrastructure is used (βn) depends on the scale of activities involving it as measured by n and its relevance for the firm's production, β. Finally, the probability that n workers using all types of infrastructure can all complete all their components is $\prod_k Q_{jk}^{\beta_{ijk} n}$. Total effective labor input is therefore $n \prod_k Q_{jk}^{\beta_{ijk} n}$.

The assumptions that the probability of failure is independent each time a worker uses the infrastructure and that if one component fails, output of the firm falls to zero are

obviously stylized, as is the assumption of a single input. However, there would be little gain from introducing more outcomes and inputs. We can interpret employment in this model as a composite input that captures "how much the firm works with the infrastructure" or "how intensively infrastructure figures in the production process" rather than as the only factor input. As we shall see below, our model leads to a measure of the cost of poor quality public inputs in terms of output lost by the firm, and the same metric would apply under more complex intermediate assumptions.

The important characteristics of this formulation of infrastructure quality are as follows:

- The most reliable infrastructure environment is when provision does not fail, i.e., Q=1. To take examples from electricity, crime prevention and customs regulation, Q=1 means respectively that there are no outages in electricity supply, no interference from crime, or that customs clearance operates in such a way that production is not interrupted. This gives us a benchmark in the model for responses in the survey of "1 – not a problem" for a particular kind of infrastructure.
- The larger the scale of operations of the firm, the more likely the firm is to encounter an infrastructure failure, e.g., an electricity interruption, crime incident, or dysfunctional court system.
- The relevance of a specific infrastructure can vary by firm characteristics – exporting firms would have a high β for customs regulation, for example. The case of $\beta_{ijk} = 0$ arises when infrastructure k is irrelevant to the firm – e.g., hairdressers and customs regulation.
- β can also vary by country characteristics. For example, transport infrastructure may be more relevant for physically large, sparsely populated countries. Country comparative advantage may also affect β. A good example is provided by Collier (2007) in his discussion of corruption. He argues that an important difference between highly corrupt but relatively successful poor countries like Bangladesh and equally corrupt but slower-growing countries such as many natural resource exporters may lie in the nature of comparative advantage and the differential vulnerability to the damage that corruption can cause. Bangladesh's reliance on low-cost manufactured textile exports created

a less tempting target for rent-seekers than the mineral resources of many African countries. This suggests that Bangladesh would have a lower β in relation to corruption than would a resource-rich country.

There are three separate parameters that determine the technological level of the firm: a standard Cobb-Douglas multiplicative parameter A_j (country-specific), another Cobb-Douglas multiplicative parameter E_{ij} (firm-specific), and the O-ring probability of infrastructure success, Q_{jk} (country- and infrastructure-specific). The usual O-ring production function has constant returns to scale in labor if all components are successful, and introduces different types of labor with assortative matching: the worker's skill level is defined by the probability that the task is completed (the O-ring), which produces an equilibrium in which highly skilled workers are matched together. We simplify the labor input side by having a single type of labor, but we allow a more flexible specification of the production technology where the labor elasticity α may be ≤1. This gives us a meaningful and standard Cobb-Douglas production function for the special case of Q=1.

Output if all n components are successful (superscript "S" for "success") is $Y_{ij}^{S} = A_j E_{ij} n^{\alpha}$, and expected firm output is therefore:

$$E(Y_{ij}) = \prod_k Q_{jk}^{\beta_{ijk} n} \left\{ A_j E_{ij} n^{\alpha} \right\} + (1 - \prod_k Q_{jk}^{\beta_{ijk} n}) \{0\}$$
$$= A_j E_{ij} n^{\alpha} \prod_k Q_{jk}^{\beta_{ijk} n} \quad .$$

Agents are assumed to be risk-neutral, and henceforth we drop the distinction between output and expected output. The firm's production function is thus

$$Y_{ij} = A_j E_{ij} n^{\alpha} \prod_k Q_{jk}^{\beta_{ijk} n} \ .$$

The first order condition for labor implicitly defines the profit-maximizing choice of employment n, i.e., labor demand, which we can write as a function of the parameters of interest and will denote with a tilda:

$$\tilde{n} = \tilde{n}(A_j, E_{ij}, W_j, Q_{jk}),$$

where W is the wage and labor demand is decreasing in the wage. The firm's supply function is the output corresponding to the optimal employment choice and is also a function of parameters only:

$$\tilde{Y}_{ij} = \tilde{Y}(\tilde{n}) = \tilde{Y}(A_j, E_{ij}, W_j, Q_{jk}).$$

The first order condition is

$$A_j E_{ij} \left\{ \frac{\alpha}{n} + \sum_k \beta_{ijk} q_{jk} \right\} n^{\alpha} \prod_k Q_{jk}^{\beta_{ijk} n} = W_j$$

and we see immediately that an increase in the technological level of the firm is equivalent to a decrease in the wage rate, which implies that the firm's labor demand (and therefore output) is also increasing in A and E. So we have

$$\frac{\partial \tilde{n}}{\partial A_j}, \frac{\partial \tilde{n}}{\partial E_{ij}} > 0; \qquad \frac{\partial \tilde{n}}{\partial W_j} < 0.$$

We can also see by inspection that labor demand (and again therefore output) is also increasing in the quality (Q) of infrastructure k. It will be decreasing in its relevance (β) since if k is more relevant to production then it will be used more intensively by a single worker increasing the likelihood of failure with the consequence that fewer workers are optimal:

$$\frac{\partial \tilde{n}}{\partial Q_{jk}} > 0; \qquad \frac{\partial \tilde{n}}{\partial \beta_{ijk}} < 0.$$

Next we show how the survey answers can be interpreted using this framework. As noted above, answers for each infrastructure type on an ordinal scale of 1-4 and are naturally scaled by the answer "1 – not an obstacle". There are two counterfactual possibilities for the output of firm i if infrastructure k was not an obstacle, depending

on whether or not employment is assumed to adjust optimally following the hypothetical infrastructure improvement that removes it as an obstacle. We do not have any evidence on whether the respondents have in mind the former or the latter, but it is simpler to work with the counterfactual in which employment is assumed not to adjust to the relaxation of the infrastructure constraint. Since the survey answers use an ordinal scale, using either of the two counterfactuals would give the same orderings and comparative statics, and there is no penalty to using the simpler (and more conservative) one in the analysis.

As we have seen, the O-ring reduces to a standard Cobb-Douglas production function if the probability of success is $Q_{jk}=1$ for all types of infrastructure, k. $Q_{jk}=1$ gives us the benchmark for "1 – not an obstacle" for each type of infrastructure. Focusing on infrastructure type k, we separate it from the rest of the infrastructure constraints, (denoted by -k) and write the actual output of firm i in country j with the current infrastructure as:

$$\tilde{\tilde{Y}}_{ij} = A_j E_{ij} \tilde{n}^{\alpha} \prod_{k} Q_{jk}^{\beta_{ijk}\tilde{n}} = A_j E_{ij} \tilde{n}^{\alpha} Q_{jk}^{\beta_{ijk}\tilde{n}} \prod_{-k} Q_{jk}^{\beta_{ijk}\tilde{n}} ,$$

where current employment $\tilde{n}$ is set optimally given current (imperfect) infrastructure provision, and $\tilde{\tilde{Y}}_{ij}$ is the corresponding optimal output. Holding employment n constant at $\tilde{n}$ and making infrastructure k "not an obstacle", we have

$$\tilde{\tilde{\tilde{Y}}}_{ijk} = A_j E_{ij} \tilde{n}^{\alpha} \prod_{-k} Q_{jk}^{\beta_{ijk}\tilde{n}} ,$$

where the k subscript on output indicates that it depends on the k^{th} infrastructure.

Since $\tilde{\tilde{Y}}_{ij} = Q_{jk}^{\beta_{ijk}\tilde{n}} \tilde{\tilde{\tilde{Y}}}_{ijk}$, the "monetary reported cost" (MRC) for firm i in country j of infrastructure k is the difference in monetary terms between output with and without the constraint. We therefore have $M\tilde{\tilde{R}}C_{ijk} = \tilde{\tilde{\tilde{Y}}}_{ijk} - \tilde{\tilde{Y}}_{ij}$, which has a very simple form:

$$M\tilde{\tilde{R}}C_{ijk} = \tilde{\tilde{\tilde{Y}}}_{ijk} - \tilde{\tilde{Y}}_{ij} = (1 - Q_{jk}^{\beta_{ijk}\tilde{n}}) \tilde{\tilde{\tilde{Y}}}_{ijk} .$$

This says that the monetary cost of constraint k reported by firm i in country j is the unreliability of k weighted by its intensity of use (i.e., its relevance times the size of the firm), multiplied by the value of output that could be produced using the current level of labor but without the constraint on infrastructure k.

We can now compare the monetary cost of two different types of infrastructure: the $\tilde{\tilde{MRC}}_{ijk}$ will be bigger, the bigger is the gain from making the infrastructure 100% reliable. However, working with the $\tilde{\tilde{MRC}}_{ijk}$ is not entirely satisfactory, because the questions asked of managers in the surveys are implicitly in relative terms rather than in monetary terms. A "moderate obstacle" will be bigger in monetary terms in a bigger firm, or in a country where average productivity is higher. We want to work instead with the cost of the constraint relative to output:

$$\tilde{\tilde{RC}}_{ijk} = \frac{\tilde{\tilde{Y}}_{ijk} - \tilde{Y}_{ij}}{\tilde{\tilde{Y}}_{ijk}} = \frac{\tilde{\tilde{MRC}}_{ijk}}{\tilde{\tilde{Y}}_{ijk}} = (1 - Q_{jk}^{\beta_{ijk}\tilde{n}}).$$

We refer to this as the (firm-level) reported cost of the constraint or RC. It is an attractive measure because it automatically translates the cost of a constraint into a share of output lost.

As already noted, the answers to these survey questions about constraints are qualitative, coded from 1 (not an obstacle) to 4 (major obstacle). We make no attempt in the empirical analysis to map this to actual percentages of firm output. However, we can use several other survey questions to get a sense of the magnitudes involved. In a number of surveys, managers were asked to quantify, as a percentage of annual sales, the costs of poor provision of electricity, telecommunications and transport, and the losses due to crime, as well as the standard questions regarding how problematic these were for their businesses using the qualitative scale discussed. The data are most plentiful for the costs of electricity outages, covering over 20,000 firms from 70 countries. The responses on the costs of power outages and surges in terms of sales are statistically strongly correlated with reporting that electricity supply is a serious obstacle to business. About one-third of firms reported zero costs due to power outages. The mean cost of electricity outages using the remaining 14,000 firms was the equivalent of 6.4% of annual sales, with a median of 3% of sales. Using the same

set of 14,000 firms, the mean evaluation of electricity supply as a constraint on business on the 1-4 scale was 2.6, and the median was "3 – Moderate obstacle". The pattern in the data for the other three public inputs is very similar, albeit based on smaller samples.[5]

We conclude that on the 1-4 scale, 2½ to 3 corresponds very roughly to an RC of 3-6% of annual sales. It is important to note, however, that this scaling is likely an understatement of the full cost imposed on firms. The quantification managers provide as answers to these questions about costs of poor public input provision corresponds to our measure $\tilde{\tilde{RC}}_{ijk}$, where the cost is also expressed in terms of actual sales/output. The measure $\tilde{\tilde{RC}}_{ijk}$ does not include the additional gain to firms by virtue of adjusting optimal employment $\tilde{n}$ upwards if the public input were to become 100% reliable. Although this doesn't matter for the analysis when we are using the qualitative 1-4 scale for the reasons already noted – the orderings and comparative statics are unaffected – it does matter for the scaling: it is likely that at least some, and possibly most, managers did not incorporate the losses from foregone firm growth and investment when quantifying in terms of annual sales the costs of power outages and so forth.[6]

2.2 Firm-level Results

How does the cost of a public infrastructure constraint reported by a firm, i.e. RC, vary with the characteristics of the firm, the type of infrastructure and the country? We focus on the relevance of observable characteristics such as those recorded in survey data and on unobservables such as the firm's technology level. The priority ranking of firms based on the survey results makes sense in this framework, allowing us to compare RCs across types of infrastructure.

[5] Thus we have data from about 2,200 firms on the costs of telecoms outages. 43% of these firms reported non-zero costs in terms of annual sales. The answers are statistically significantly correlated to the answers to the question about telecommunications provision as an obstacle to business. The mean response of this set of firms to the latter question is 2.1, and the median is "2 – Minor obstacle". The mean cost of outages is 5% of annual sales, with a median of 2% of sales, suggesting a somewhat higher cost than the calibration based on electricity supply. Calibration using the 1,400-odd firms that reported the costs of transport outages implies that 2.6 on the 1-4 scale corresponds to 2-5% of annual sales, and calibrating using the roughly 900 firms that answered the question of how much crime costs them suggests that 2.8 on the 1-4 scale corresponds to 1-4% of sales.

[6] The calibration is also an understatement in the narrow sense that gross sales by the firm is typically double or more its value added.

We have the following within-country results. First,

$$\frac{\partial \tilde{\tilde{RC}}_{ijk}}{\partial \beta_{ijk}} > 0$$

i.e., the more critical is infrastructure k, the higher the reported cost (RC) of the constraint. Relevance may vary with firm characteristics such as sector, exporter status, and ownership status as well as with country characteristics. Firm size is endogenous in the model and to show how the reported cost of a constraint varies with the productivity parameters, we note that a rise in a productivity parameter raises current employment $\tilde{n}$, which cet. par. increases the intensity of use of infrastructure k (raising the probability of infrastructure failure $\left(1-Q_{jk}^{\beta_{ijk}\tilde{n}}\right)$). This means that the gap between current output and output under the counterfactual response whereby the infrastructure is rated as "1 – not an obstacle" goes up, which is what is measured by the reported cost $\tilde{\tilde{RC}}_{ijk}$. We therefore have

$$\frac{\partial \tilde{\tilde{RC}}_{ijk}}{\partial E_{ij}} > 0 \quad , \quad \frac{\partial \tilde{\tilde{RC}}_{ijk}}{\partial A_j} > 0 .$$

Finally, improvements in infrastructure lower the RC reported by the firm:

$$\frac{\partial \tilde{\tilde{RC}}_{ijk}}{\partial Q_{jk}} < 0 .$$

Fig. 1 illustrates how RC varies with the firm-level productivity parameter, E_i (Fig. 1a) and with country infrastructure provision, Q_j (Fig. 1b)

Figure 1. Variation of the reported cost of a public infrastructure constraint

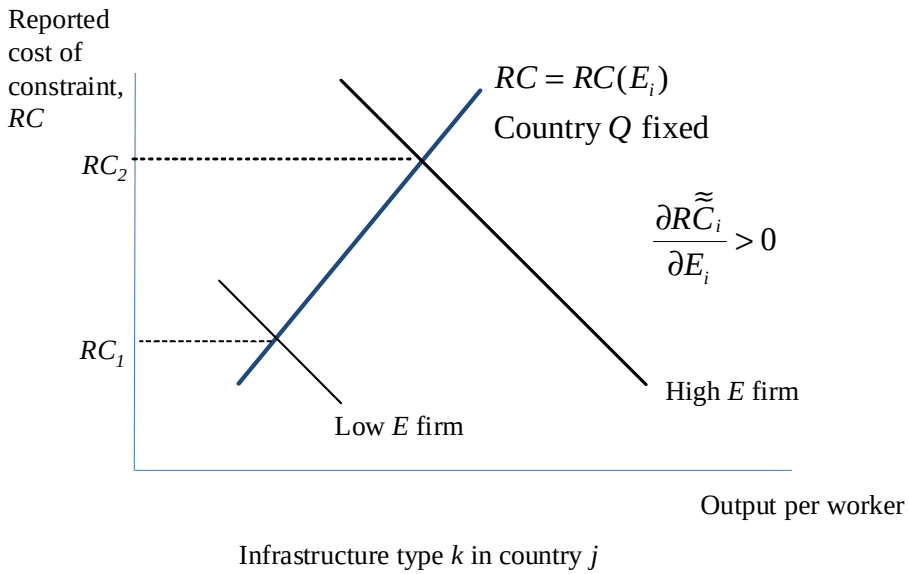


Fig. 1a: RC varies with firm productivity, holding country infrastructure provision constant

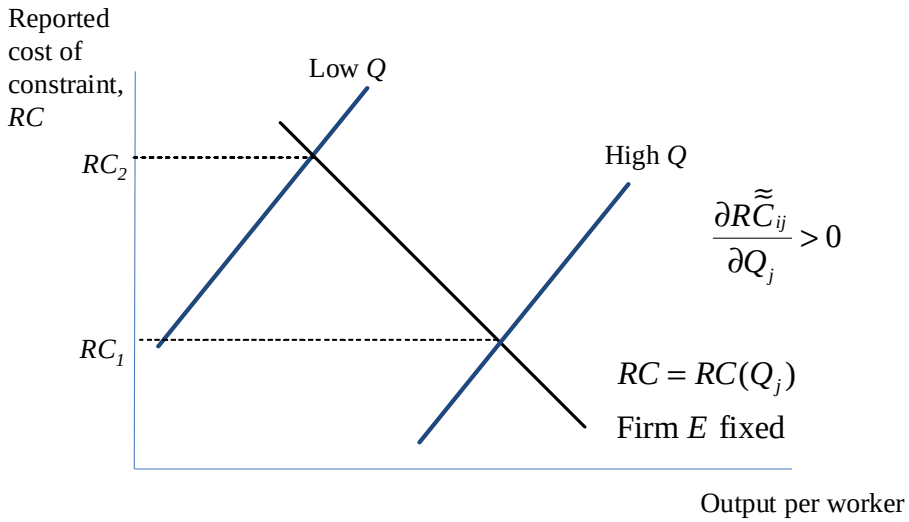


Fig. 1b: RC varies with country infrastructure provision, holding firm productivity constant

2.3 Aggregating

For our framework to be useful, we need to be able to aggregate responses across firms within a country and to compare average reported costs of constraints across countries. An advantage of the probabilistic formulation of the RC, $\tilde{\tilde{RC}}_{ijk} = (1 - Q_{jk}^{\beta_{ijk}\tilde{n}})$, is that it allows us to do this. The mean for infrastructure k in country j is

$$\tilde{\tilde{ARC}}_{jk} = \frac{1}{N}\sum_i \tilde{\tilde{RC}}_{ijk} = \frac{1}{N}\sum_i (1 - Q_{jk}^{\beta_{ijk}\tilde{n}}).$$

where N is the number of firms. The average reported cost of constraint k for country j (i.e. the ARC) is well defined: it is the average probability that infrastructure k fails for a firm in country j. This is bigger the more intensively this type of infrastructure is used in country k, which in turn will reflect its relevance for output in that country (β) and the average size of firms (n).

We have already seen that a rise in country productivity increases the reported cost of the constraint, i.e. $\frac{\partial \tilde{\tilde{RC}}_{ijk}}{\partial A_j} > 0$. It therefore follows that $\frac{\partial \tilde{\tilde{ARC}}_{jk}}{\partial A_j} > 0$, and ceteris paribus, we would expect an upward-sloping line when we plot the country means of the reported cost of constraint against GDP per capita, which is our proxy for country productivity. However, ceteris is not paribus, and we also expect investment in improvements in infrastructure as countries get richer.

Since the firm's reported cost of a constraint falls as infrastructure supply increases, i.e., $\frac{\partial \tilde{\tilde{RC}}_{ijk}}{\partial Q_{jk}} < 0$, this is also true of the average reported cost, so we have $\frac{\partial \tilde{\tilde{ARC}}_{jk}}{\partial Q_{jk}} < 0$. And since we expect that as countries get richer, infrastructure quality improves, i.e., $\frac{\partial Q_{jk}}{\partial A_j} > 0$, this implies that the net impact of country productivity on the ARC is ambiguous.

Although we do not model the infrastructure supply process, we can use our model to provide some intuition about the relationship between the ARC and GDP per capita. It is useful to define the rate of return on the investment required to make infrastructure k 100% reliable as

$$r_{jk} = \frac{\sum_i MRC^*_{ijk}}{I_{jk}} = \frac{1}{N}\sum_i \frac{MRC^*_{ijk}}{I_{jk}/N},$$

where I_{jk} is the total (country-level) cost of the investment required to do this and $MRC^*_{ijk} = Y^*_{ijk} - \tilde{Y}_{ij} > M\tilde{\tilde{R}}C_{ijk}$ is the increase in output that would take place if infrastructure k was brought up to 100% reliability *and* employment was adjusted optimally to this change.

Since we can also rewrite the ARC as

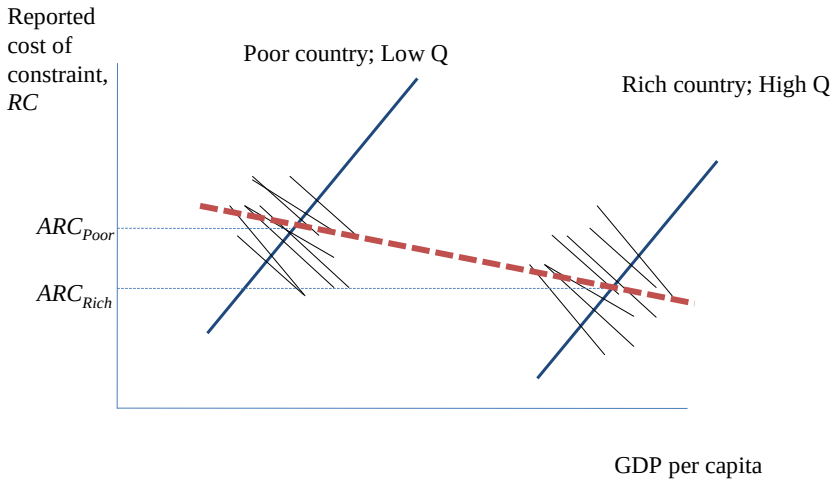
$$A\tilde{\tilde{R}}C_{jk} = \frac{1}{N}\sum_i R\tilde{\tilde{C}}_{ijk} = \frac{1}{N}\sum_i \frac{M\tilde{\tilde{R}}C_{ijk}}{\tilde{\tilde{Y}}_{ij}},$$

we expect these two measures to be correlated. The numerators are closely related, and the denominators should also be correlated (in the first case, it is the investment needed per firm; in the second case, it is a measure of firm size; and the investment needed per firm will tend to be larger when firms are larger). This suggests that if we think that the rate of return on a particular type of infrastructure investment tends to be higher in poor countries relative to the return in rich countries, then we have, a priori, reason to think that the income–constraint locus will be downward sloping.

It is also the case that if we believe that the relationship between GDP per capita and the ARC of a constraint is systematic across countries, then we can infer something from where a country is in ARC–GDP per capita space as compared with the systematic relationship observed, i.e., an estimated regression line. Thus if the typical firm in country j reports that, for its level of GDP per capita, the ARC for infrastructure k is high compared to the regression line (a positive residual), then unless this is noise, it could either reflect the fact that the local cost for improving infrastructure k is high relative to that in other comparable countries, or that there is a

social investment opportunity. In Fig. 2, the regression line is shown as dashed: in this example, for infrastructure k, the ARC falls as GDP per capita rises.

Fig. 2 The income–constraint locus (dashed line) for infrastructure k



We can make the same sort of inference based on comparisons across different types of infrastructure. If the typical firm in country j reports that infrastructure k is ranked as the number 1 obstacle, whereas the typical firm in the typical country with the same GDP per capita ranks it as a less important obstacle, then once again if this is not noise, either the local cost for improving infrastructure k is high relative to that in other countries, or there is a social investment opportunity. As we shall see in Section 4, this provides useful information to the policy maker. We turn now to the data to check their consistency with the framework proposed.

3. Verifying the Plausibility of the Reported Cost Measures with Survey Data

3.1 The Value of Survey Data

Our data consist of the answers given by firm managers to questions asking them to identify the specific goods and services whose availability acts as a constraint on their economic activity. In principle, if these responses (the reported costs of constraints) are accurate and representative of the wider population, we should obtain a reliable picture of the constraints that matter for the activity of the economy as a whole. So how accurate and representative can we expect them to be?

The question of how representative are the responses is easiest to answer. Enterprises are not the only economic agents that matter in an economy. There are also individuals and households – and some institutions that matter for them do not matter very much for the activity of firms. More subtly, existing enterprises are not perfectly representative of the population of potential enterprises (namely those that would exist under better institutional conditions). There may be some types of regulation, for instance, that are not perceived as constraints by existing firms but which serve to make entry into the market much more difficult for new firms. These caveats should be borne in mind in interpreting the results of a study like the present one, but it remains an important exercise in our view to study the relative importance of constraints on the activity of existing firms.

The question of accuracy is more complex. There are of course doubts about the willingness and ability of managers to report accurately features of their firm's environment, especially those embodied in not-easily-quantifiable measures such as "degrees of severity". Biases such as over-optimism or a tendency to complain may affect estimates of the true severity of these constraints. However, there is no particular reason to think, in most cases, that average differences in the reported severity of different constraints are likely to be biased. If, on average in a given economy, firms report tax administration to be a more severe constraint than transport infrastructure, it seems likely that tax administration is indeed the bigger constraint upon economic activity in the economy (in the sense that an increase in its reliability would result in a larger increase of firms' output than would a comparable increase in the quality of the transport network).

However, there are some kinds of institutional feature included in the manager surveys where there may be doubts about accuracy that do indeed affect differences in reported severity. Most important among these are the responses regarding availability of finance and tax rates. If finance had the character of a public good like telecoms or customs regulation one could interpret a high score on the constraints measure as indicating that output would respond strongly to an increase in the availability of finance. But finance is different – banks lend money to managers whose interests are not identical to those of shareholders, and shareholders in turn do

not internalise the full costs of their borrowing decisions, due to limited liability. Increased availability of finance may enable profligate managers to fund pet projects that, on average, do not increase economic activity but which merely increase default rates, the costs of which are borne by lenders. A perception that the supply of finance is a constraint on the activity of at least some managers is something that should characterize an effective set of financial institutions, unlike in the case of institutions such as physical infrastructure or the legal system. Finance has the additional feature that – if the institutions are working well – the perception of its availability as a constraint should be inversely related to the quality of investment projects the firm has available to fund, so that high scores may indicate poor quality projects rather than the potential for increased output.

The interpretation of the responses of managers as to the importance of tax rates for the operation of their business is best thought of, not as suggesting a priority to reducing taxes, but as pointing to the costs imposed on firms if public inputs are supplied at the cost of higher taxes than necessary. Although the tax rate is very highly ranked as a constraint by managers in virtually all countries (irrespective of their level of development), it does not follow that it is a priority everywhere to cut taxation. A more appropriate interpretation is that policies to reduce tax rates while holding other aspects of public infrastructure provision constant (for instance, by improving administrative efficiency) would improve firm performance.

In sum, therefore, the perception of the relative importance of different institutional constraints on firm activity does appear to tell us something of importance for policy, provided we remember both that they tell us only about constraints on existing firms and that financial constraints need to be identified in a quite different way from those associated with institutions that have the character of public goods.

3.2 The Data

The data we use are the fruit of a vast effort over the past decade to collect firm-level data on the quality of the institutional environment in which firms operate. Both the World Bank and the EBRD have undertaken large numbers of firm level surveys with the express intention of measuring the quality of the "business environment" or the "investment climate". We use data from some 197 cross-sectional surveys covering

over 72,000 firms located in 95 countries.[7] The surveys are based on random samples of non-agricultural firms, usually stratified on size, sector and ownership.

These "business environment" surveys focus on physical infrastructure and institutions, interpreted as the rules of the game in which firms are engaged, the organizations that implement these rules and the services provided. They gather information through face-to-face surveys on a firm's experience of physical and communications infrastructure (e.g., outages and connection delays), legal and regulatory institutions (e.g., bribes paid to get things done, losses due to crime, delays at customs posts), and the financial system (e.g., collateral required on loans). They also gather information on the assessment by managers of the importance of each aspect of the business environment for the operation and growth of the firm. The question asked of the manager is:

> "I would now like to ask you questions about the overall business environment in your country and how it affects your firm. Can you tell me how problematic are these different factors for the operation and growth of your business?"

The managers responded on a 4-point scale, "No obstacle (1)" to "Major obstacle (4)". As noted above, only a subset of the questions included in the surveys is suitable for analysis using the framework we have introduced. In particular, since answers to the finance and tax rate questions cannot be interpreted in the framework of a public infrastructure input, we exclude them from this study.

Economists have typically used these data as a right-hand side variables in an augmented TFP equation (e.g., Commander and Svejnar, 2010, Dollar, Hallward-Driemeier and Mengistae, 2005, and Hallward-Driemeier and Aterido, 2009). In such a setting the data are interpreted as measuring the availability of public infrastructure to the firm rather than the impact of its reliability on the output of the firm.[8] Policy advisors have often used the raw data for their country of interest (e.g., EBRD *Transition Reports*). Our proposed framework both shows how the data can be

[7] As explained in the Data Appendix, the full data-set includes 81,000 firms from 206 surveys with information on constraints – the smaller sample also includes information on firm characteristics. In Table 1 we use both conditional and unconditional means and the results of the country-level analysis using the unconditional means were similar to those reported in the paper.

[8] Carlin, Schaffer and Seabright 2007 provides a detailed critique of such use of the data.

interpreted in the context of an economic model and how they can be used by policy makers.

It is worth noting that our framework allows us to reconcile our findings with the generally negative results of Commander and Svejnar (2010). These authors estimate a firm-level production function with a number of the same survey measures of infrastructure as independent variables. When they use firms' own reported measures, the coefficients are rarely significant, though their significance increases when the authors use as instruments the values reported by other firms in the same country, 2-digit industry and size class, which is consistent with our own arguments about the likely endogeneity of the measures. However, most such measures become insignificant once country fixed effects are included, and when all 9 are included together, no one measure is significant.

These findings make sense once it is noted that public infrastructure is a country-level public good, so that its availability does not vary between firms in a country. Own-firm evaluations of the cost of infrastructure unreliability will generate an inverse relationship between firm productivity and the quality of infrastructure; the two effects together meaning that we cannot expect to recover the impact of infrastructure on performance from the regression coefficient. However, as we have indicated, the values of the reported costs themselves can indeed be interpreted as measures of the impact of infrastructure on performance, and in a way that allows that impact to vary from country to country.

3.3 How the responses vary across firms

The firm-level reported cost of constraint k, $\tilde{\tilde{RC}}_{ijk} = (1 - Q_{jk}^{\beta_{ijk}\tilde{n}})$ will vary with: (a) observable firm-level characteristics such as size and sector that are correlated with how frequently the firm makes use of public input k and how important k is to the firm; (b) unobservables such as the firm's idiosyncratic productivity E_{ij} that are similarly correlated; (c) the scale of provision Q_{jk} of public input k in country j. Whereas in cases (a) and (b) we expect $\tilde{\tilde{RC}}_{ijk}$ to vary with firm-level characteristics,

we think of Q_{jk} as constant for all firms in a country, but varying systematically across countries according to their level of development, i.e., $Q_{jk} = Q_{jk}(A_j)$.

Our estimation framework is a simple linear regression that lets us separate the within-country variation across firms driven by firm-level characteristics, and the between-country variation that we hypothesize is driven, inter alia, by the country level of development. The main estimating equation for each type of infrastructure can be written

$$\tilde{\tilde{RC}}_{ijk} = a_{jk} + X_{ij}\Gamma_k + e_{ijk} \qquad (2.1)$$

where X_{ij} is a vector of observable firm characteristics, a_{jk} and Γ_k are infrastructure/country- and infrastructure-specific parameters to be estimated, and e_{ijk} is a firm-level error term with mean zero. The parameter a_{jk} varies only at the country level, whereas X_{ij} and e_{ijk} vary at the firm-level. The firm characteristics X_{ij} are defined to give us a "benchmark firm" when all characteristics are zero, $X_{ij} = 0$ (e.g., the reference categories of dummy variables). The benchmark firm has 30 employees,[9] is in manufacturing, is privately owned with no state-owned predecessor, has less than 10% foreign ownership and exports less than 10% of its sales and has no reported change in employment in the previous three years. This hypothetical benchmark firm is the same for all countries.

We use the within-country variation in the data to identify Γ_k, estimate it using the standard fixed effects estimator, and report these as our "within" results. We interpret our estimates $\hat{\Gamma}_k$ as capturing the observable firm-level correlates (a) of the reported cost of the constraint to the firm, and the fixed effects residual $\hat{e}_{ijk}$ as capturing the unobservable components (b), including (unobserved) idiosyncratic firm productivity.

[9] The median firm in the survey has 28 employees, and the mean of log employment is the equivalent of 33 employees, so we choose 30 as the nearest round number.

The same fixed-effects estimation allows us to calculate a conditional average reported cost of constraint k:

$$\hat{a}_{jk} \equiv \frac{1}{N}\sum_i \left(\tilde{\tilde{RC}}_{ijk} - (X_{ij}\hat{\Gamma}_k + \hat{e}_{ijk}) \right) = \frac{1}{N}\sum_i \left(\tilde{\tilde{RC}}_{ijk} - X_{ij}\hat{\Gamma}_k \right) \qquad (2.2)$$

since, as usual, by construction the mean of the fixed effects residual $\hat{e}_{ijk}$ is zero for each country. The parameter a_{jk}, and its estimate, the conditional mean $\hat{a}_{jk}$, can be thought of as the $\tilde{\tilde{RC}}_{ijk}$ that would be reported by country j's "benchmark firm" – a firm in country j that had $X_{ij} = 0$. We adopt this procedure in order to eliminate differences in the average reported constraint that are driven simply by sample composition (e.g., in the balance of manufacturing and services firms in a particular survey). Recall that $\tilde{\tilde{RC}}_{ijk} = (1 - Q_{jk}^{\beta_{ijk}\tilde{n}})$. Because we are removing some of the cross-country variation in $\beta_{ijk}\tilde{n}$ that is driven by cross-country variation in firm characteristics, the conditional mean $\hat{a}_{jk} \equiv \frac{1}{N}\sum_i \left(\tilde{\tilde{RC}}_{ijk} - X_{ij}\hat{\Gamma}_k \right)$ will be more closely correlated with Q_{jk} than the unconditional mean $\tilde{\tilde{ARC}}_{jk} = \frac{1}{N}\sum_i \tilde{\tilde{RC}}_{ijk}$.

We then use the conditional mean $\hat{a}_{jk}$ in a cross-country regression on GDP per capita:

$$\hat{a}_{jk} = b_{0k} + b_{1k}Y_j + b_{2k}Y_j^2 + u_{jk} \qquad (2.3)$$

where Y_j is GDP per capita and proxies for the country-level productivity parameter A_j. We allow for a non-linear relationship with GDP per capita. This estimation yields predictions $\hat{\hat{a}}_k$ for what "benchmark" firms in "typical" countries would report as the cost of constraint k. The residual $\hat{u}_{jk} \equiv \hat{a}_{jk} - \hat{\hat{a}}_k$ is interpreted as the difference between what a benchmark firm reports as the cost of constraint k and what a benchmark firm in a typical country with the same GDP per capita would report.

3.4 Conditional and unconditional means for each type of public infrastructure

Table 1 shows the unconditional and conditional means for each type of public infrastructure. The conditional means control for differences in the sample characteristics across countries. The conditional mean for the average of six elements of infrastructure (that are present in all surveys) is below the unconditional mean but the differences between the two measures are sufficiently small as not to affect the ranking of constraints. The macroeconomic environment is the top-ranked constraint followed by policy uncertainty, tax administration, corruption, and electricity. At the bottom of the scale are transport, land access, and telecoms.

In the lower part of the table, we report average responses for a series of quantitative indicators of the experience of firms with aspects of public infrastructure. These include power and water outages, bribes, under-reporting to the tax authorities, and gifts to government officials. All of these variables are of the zero/one type, where one indicates that the firm reports the events.

Table 1. Unconditional and Conditional Means of Reported Constraints

			Slope of income-constraint locus		
	Unconditional mean	Conditional mean	Low income (appx $1,000)	Medium income (appx. $6,000)	High income (appx. $20,000)
Average of 6 indicators	2.29	2.24	0.086	-0.088*	-0.204*
Infrastructure (composite)	1.94	1.95	-0.252**	-0.164**	-0.105
Telecoms	1.75	1.68	-0.079	-0.074*	-0.071
Electricity	2.20	2.23	-0.490**	-0.308**	-0.186
Transport	1.87	1.83	-0.250**	-0.118**	-0.031
Land Access	1.81	1.79	-0.132*	-0.110**	-0.096
Skills	2.18	2.12	0.023	0.057	0.079
Macroeconomic Instability	2.72	2.67	-0.001	-0.159**	-0.263*
Policy Uncertainty	2.71	2.65	0.362**	-0.182**	-0.546**
Tax Administration	2.49	2.45	-0.004	-0.112*	-0.183
Labor Regulation	1.90	1.86	0.069	0.159**	0.218**
Customs	2.01	1.91	0.006	-0.168**	-0.284**
Licences	1.98	1.91	0.089	-0.061	-0.160*
Legal	2.04	1.99	0.203*	-0.016	-0.162
Corruption	2.44	2.38	0.286**	-0.268**	-0.638**
Crime	2.18	2.10	0.123	-0.205**	-0.424**
Power Outages (y/n)	0.58	0.58	-0.123**	-0.131**	-0.136**
Water Supply Outages (y/n)	0.24	0.23	-0.047	-0.101**	-0.137**
Bribes (y/n)	0.55	0.52	0.065	-0.033	-0.098
Don' t Report All Sales (y/n)	0.67	0.67	0.241	-0.075	-0.286
Tax Gifts (y/n)	0.31	0.31	0.014	-0.058*	-0.106
Contract Gifts (y/n)	0.35	0.33	-0.064	-0.045*	-0.033

Notes: ** denotes significance at 1%; * at 5% and estimates are robust to country clustering and heteroskedasticity.

3.5 How reported costs vary with firm characteristics (within-country)

Table 2 reports our "within" estimates of $\hat{\Gamma}_k$ from the standard fixed effects estimator of $\tilde{\tilde{RC}}_{ijk} = a_{jk} + X_{ij}\Gamma_k + e_{ijk}$, where X_{ij} is the vector of observable firm characteristics. Observable firm characteristics available in the survey data are those used to construct the conditional means reported in Table 1. They are size (log employment), whether or not employment expanded or contracted in the past three years, sector (manufacturing, services, and construction), ownership (state, privatized, private, extent of any foreign ownership), and exporter status.[10]

Table 2 shows that across virtually all types of infrastructure, there is a positive firm size effect, which is significant at least at the 5% level. As firm size increases, the share of output lost due to unreliable or inadequate public infrastructure rises. Larger firms are often better placed to take advantage of the public infrastructure supply and yet they report it as being more of a constraint on their activities. The data are therefore consistent with the prediction of the O-ring framework that the reported cost of a constraint is increasing in firm size.[11] The O-ring effect comes both directly through the scale of use and indirectly though the effect of higher productivity in inducing larger firm size. The only elements of public infrastructure where there is no apparent size effect are access to land and corruption.

Firms that expanded their employment in the previous three years report significantly higher costs across all types of infrastructure than do firms with stable employment. Contracting firms also report higher costs of constraints than do stable firms, except for telecoms, electricity and access to land. Although the macroeconomic environment and policy uncertainty are more burdensome for expanding than stable firms, they appear to be even more costly for contracting firms. The same is true of labor regulation and the legal system.

[10] Significant export activity is defined as exports in excess of 10% of sales; significant foreign ownership is defined as foreign ownership in excess of 10%. We include dummies for majority state ownership and 100% state ownership because the most recent round of surveys in 2007-09 excluded 100% state-owned firms (but allowed up to 99% state ownership!).

[11] Although the reported cost of the unreliability of electricity supply rises with firm size, the lower part of Table 2 reports that there is no significant relationship between firm size and whether a power outage is reported. This is also consistent with the O-ring interpretation.

Table 2. Within-country estimates of public infrastructure constraints

	Size (log L)	Expanding	Contracting	Services	Construction	Privatized	State-owned	100% SOE	Foreign	Exporter
Average of 6 indicators	0.023**	0.088**	0.109**	0.028	0.077**	-0.078**	-0.160**	-0.120**	-0.029*	0.019
Infrastructure (composite)	0.024**	0.052**	0.024	-0.039	-0.086**	-0.061**	-0.081**	-0.024	0.017	0.023
Telecoms	0.016**	0.070**	0.016	0.068	-0.011	-0.062**	-0.042	-0.029	0.053**	0.047*
Electricity	0.019**	0.052**	0.024	-0.103**	-0.188**	-0.083**	-0.037	-0.080	-0.029	0.010
Transport	0.041**	0.066**	0.045**	-0.012	-0.024	-0.072**	-0.117**	0.005	0.043**	0.068**
Land Access	0.005	0.104**	0.028	-0.022	0.126**	-0.150**	-0.195**	-0.028	-0.062**	-0.018
Skills	0.078**	0.154**	0.135**	-0.087**	0.029	-0.090**	-0.082*	-0.028	-0.047**	0.037*
Macroeconomic Instability	0.019**	0.090**	0.154**	-0.042	-0.057	-0.050	-0.147**	-0.100*	-0.027	0.092**
Policy Uncertainty	0.026**	0.104**	0.181**	-0.028	0.001	-0.051	-0.127*	-0.087	-0.022	0.038
Tax Administration	0.015*	0.070**	0.107**	0.009	0.062**	-0.091**	-0.167**	-0.176**	-0.019	0.052*
Labor Regulation	0.070**	0.069**	0.115**	-0.036	0.021	-0.089**	-0.081*	-0.069	-0.025	0.068**
Customs	0.079**	0.113**	0.076**	-0.018	-0.163**	-0.173**	-0.287**	-0.103*	0.208**	0.313**
Licences	0.027**	0.106**	0.091**	0.043	0.075*	-0.093**	-0.208**	-0.125**	0.005	0.041*
Legal	0.055**	0.054**	0.115**	0.010	0.075**	-0.091**	-0.106*	-0.110**	0.017	0.052**
Corruption	0.009	0.102**	0.124**	0.022	0.140**	-0.129**	-0.213**	-0.137**	-0.018	0.022
Crime	0.015*	0.077**	0.072**	0.163**	0.122**	-0.070**	-0.123**	-0.032	-0.053**	-0.044*
Power Outages (y/n)	0.004	0.042**	0.030**	-0.018	-0.091**	-0.050**	-0.051**	-0.013	-0.010	-0.003
Water Supply Outages (y/n)	-0.005**	0.021**	0.017**	0.012	-0.013	-0.020*	-0.012	-0.009	-0.008	-0.008
Bribes (y/n)	0.004	0.046**	0.051**	0.016	0.092**	-0.048**	-0.125**	-0.067*	-0.017*	0.013
Don' t Report All Sales (y/n)	-0.058**	0.028	0.020	0.015	0.044	0.004	-0.121**	0.030	-0.114**	0.057*
Tax Gifts (y/n)	0.000	0.029**	0.024**	-0.004	0.023	-0.064**	-0.062*	-0.090**	-0.029**	0.004
Contract Gifts (y/n)	-0.004	0.036**	0.039**	-0.001	0.117**	-0.046**	-0.088**	-0.012	-0.016	-0.008

Notes: The coefficients show the marginal effects relative to the omitted category except for size, where the coefficient is an elasticity.
** denotes significance at 1%; * at 5%. Estimates are robust to heteroskedasticity and clustering on country.

Sectoral characteristics are also consistent with the O-ring interpretation of the relevance of the type of infrastructure: services and construction firms report lower costs associated with electricity, reflecting a lower expected share of output lost from unreliable supply as compared with firms in manufacturing. Crime is reported as imposing higher costs on firms in these sectors, relative to manufacturing firms. The lower skill-intensity of services technology is also reflected in the reported costs. Construction firms report access to land, tax administration, the legal system and corruption as more costly than do manufacturing firms. Plausibly, they report lower costs from customs regulation.

The ownership data indicate that private firms (without any state-owned predecessor) report higher costs of constraints than do privatized or state-owned ones. They are also more likely to report that "firms like theirs" pay bribes and gifts to public officials. These seem to be especially onerous in relation to access to land, tax administration, customs regulation, licenses and corruption. Foreign-owned firms typically report lower costs of constraints with the exceptions of telecoms, transport and especially customs regulation. They are significantly less likely to report the payment of bribes and gifts to public officials than is the case for domestically owned firms. Exporting firms echo the concern of foreign-owned firms about customs regulations, telecoms and transport but also report higher constraints than non-exporters for macroeconomic stability, skills and most of the institutional constraints.

Foreign ownership and exporter status are both proxies in the data for firm-level productivity (Commander and Svejnar, 2010). Consistent with the model, exporters report higher constraints across of wide range of public infrastructure. However, this is not true of foreign-owned firms, which suggests that they may be able to substitute for public infrastructure using internal resources or because of special arrangements with host governments. Foreign-owned firms report lower constraints for skills and crime (reflecting the former) and access to land (reflecting the latter). Although information on manager education is only available for a subsample of surveys, it provides a useful robustness check as an additional proxy for TFP. When added to the other firm characteristics in the within-equation, there is a positive and significant coefficient on manager education for all constraints except land access and crime. Firms with more highly educated managers report higher costs of constraints.

In sum, the empirical results using variation across firms are consistent with the predictions from our framework: larger and higher-productivity firms generally report higher RCs, and the variations in RCs across different types of public inputs are plausibly correlated with the differing intensities with which different types of firms use these inputs. Since the information content of the variation across firms in RCs is consistent with the model, we can move to the next step in the analysis, which is to use the coefficients reported in Table 2 to calculate the country conditional means $\hat{a}_{jk}$ and examine how these vary with GDP per capita.

3.6 How reported costs vary with GDP per capita

The O-ring production function models the demands placed on public infrastructure by firms. Since, ceteris paribus, an increase in a country's productivity proxied by GDP per capita raises the demands on public infrastructure, richer countries should report higher costs of constraints. However, as noted in Section 2, although we do not have a model of infrastructure supply, we can hypothesize that as GDP per capita rises, the quality of public infrastructure improves. To the extent that returns to infrastructure investment are especially high in low-income countries, we would expect a downward-sloping relationship between the average reported cost of infrastructure and GDP per capita.

The right-hand side of Table 1 reports the slope of each income–constraint locus at low, medium and high levels of per capita income. These patterns are shown graphically in Figure 3, where the average reported cost of the constraint for each survey is plotted against the log of country GDP per capita in purchasing power parity. Fig. 3a shows the regression line for the average over six types of public infrastructure. Table 1 and Fig. 3 highlight the variation in the slopes of the income–constraint loci. For the elements of physical infrastructure (including access to land), the loci slope downward with reported costs of constraints falling as income rises, although the negative slopes are not significant at high incomes. The downward-sloping pattern for physical infrastructure is illustrated in the composite measure (Fig. 3b).

Figure 3. Income–constraint loci for selected public infrastructure constraints

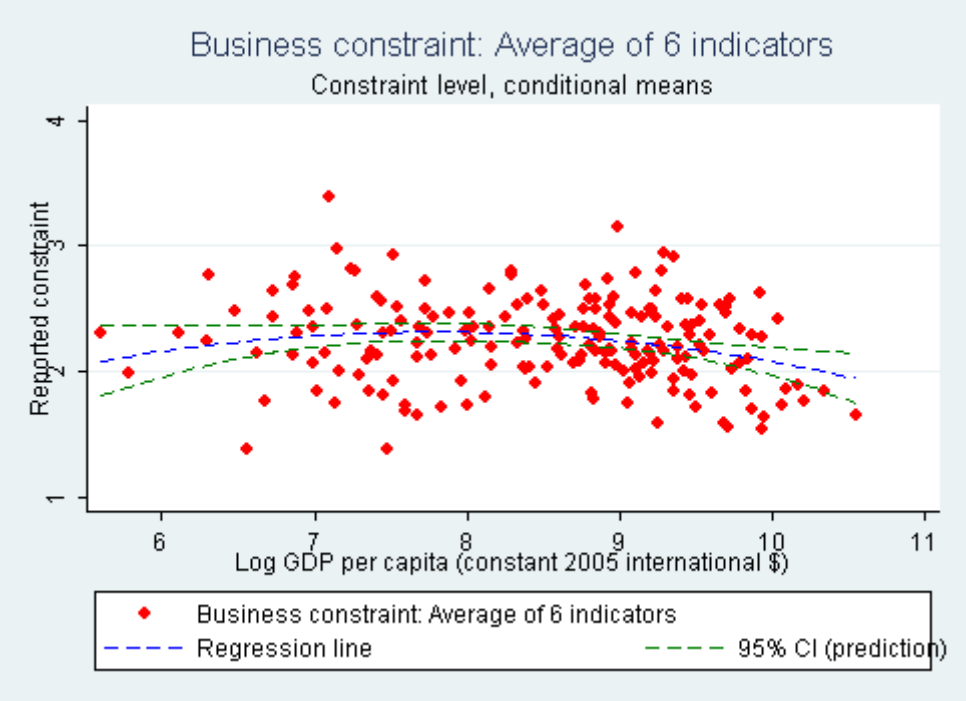


Fig. 3a. Average of 6 indicators

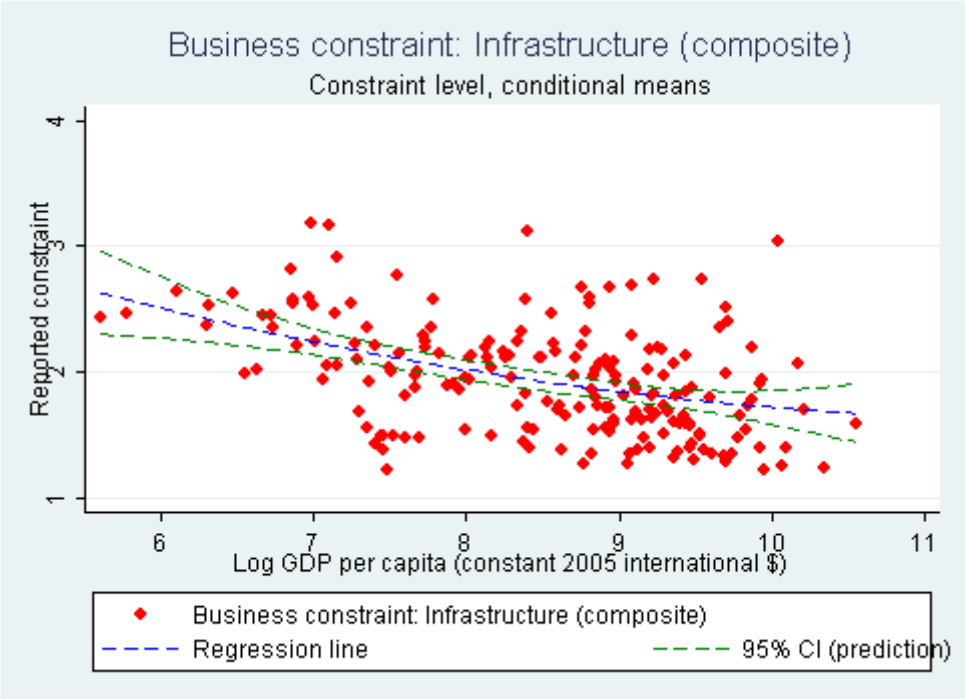


Fig. 3b. Composite measure of physical infrastructure

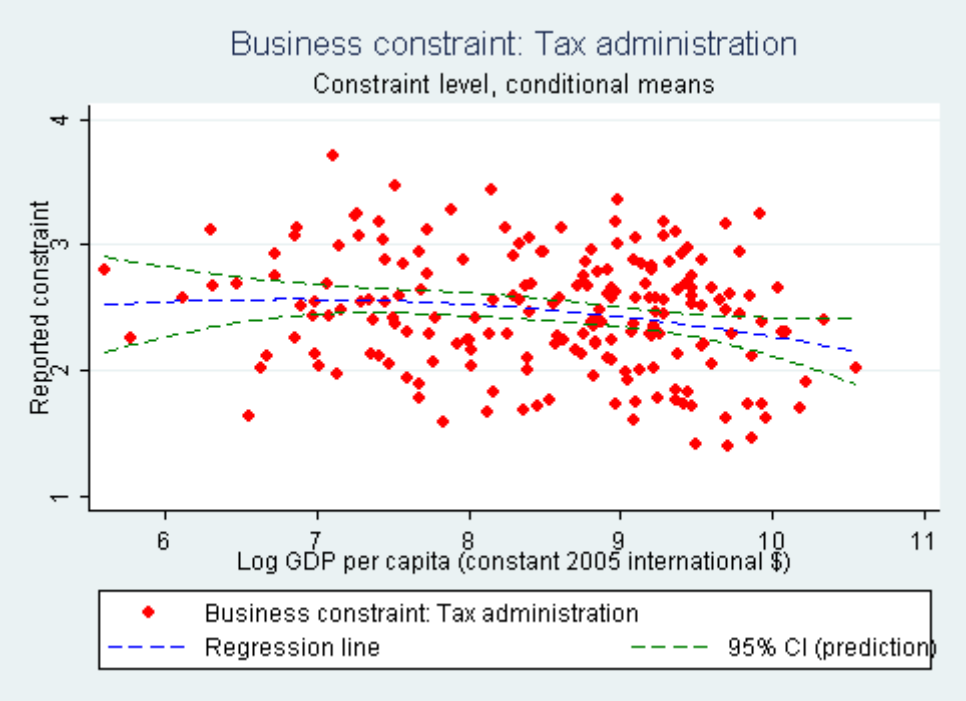


Fig. 3c. Tax administration

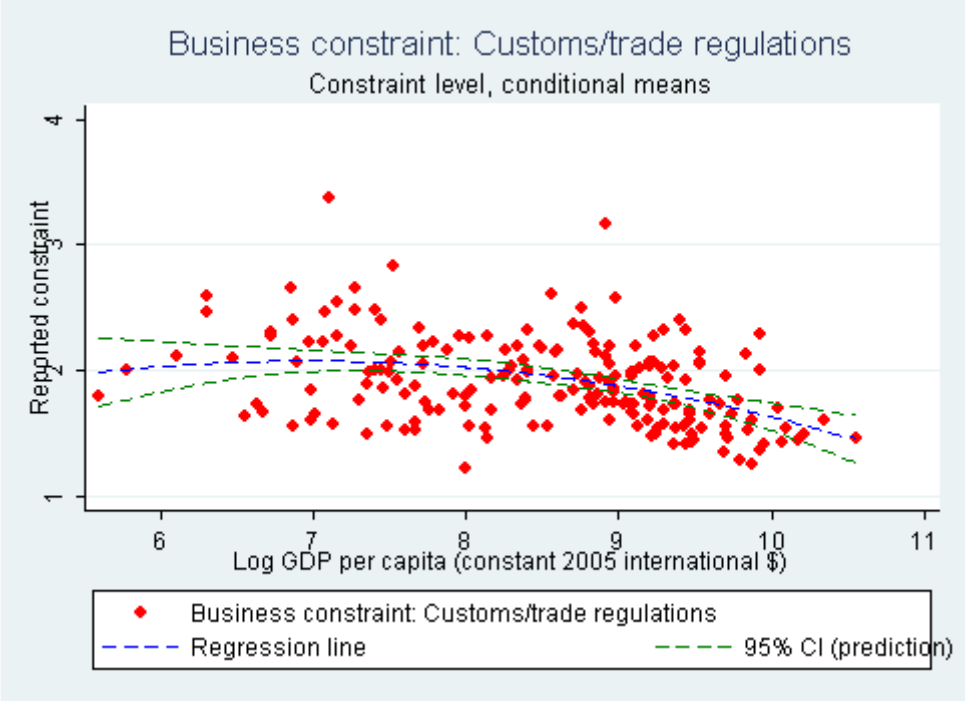


Fig. 3d. Customs/trade regulations

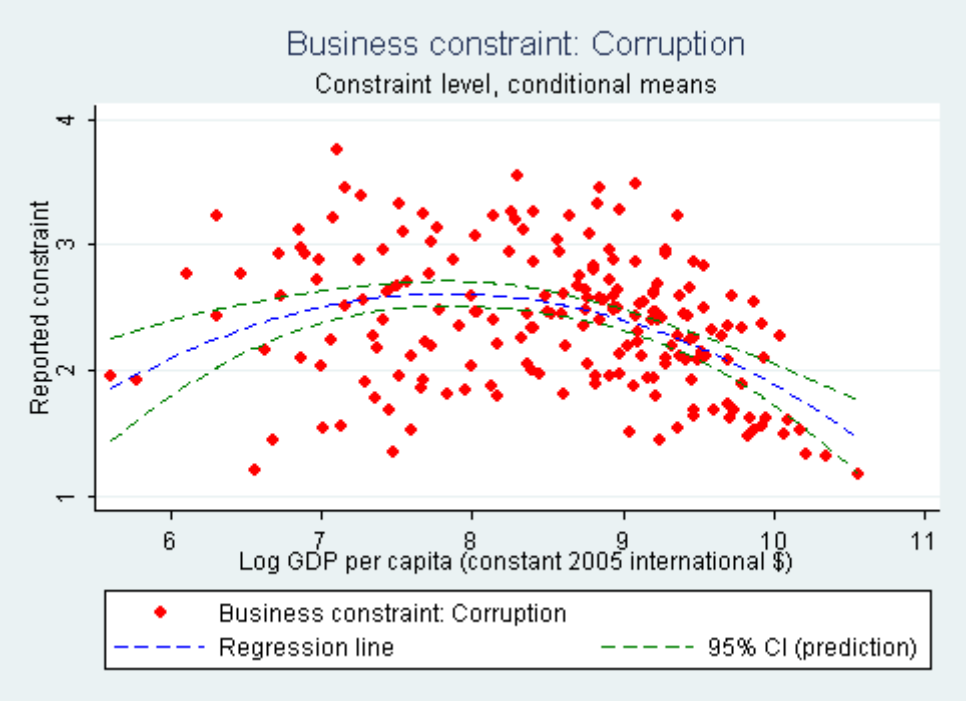


Fig. 3e. Corruption

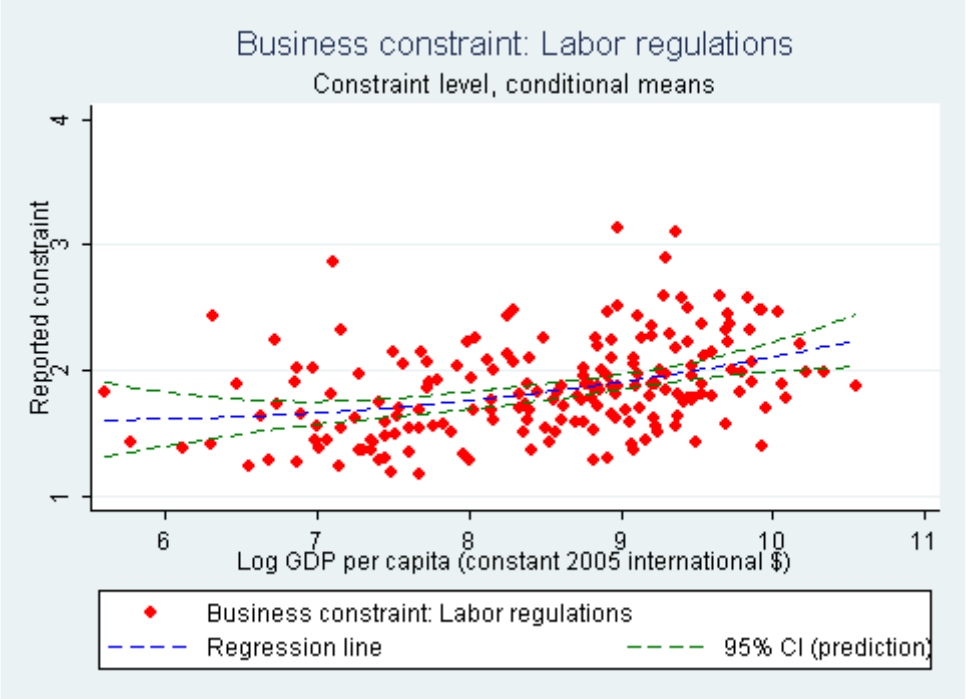


Fig. 3f. Labor regulations

The income–constraint loci for the macroeconomic environment, tax administration and customs are also downward sloping from the middle of the income distribution, although in these cases, the slope gets steeper at high incomes. Fig. 3c and 3d show the loci for tax administration and customs/trade regulations, respectively.

Both policy uncertainty and corruption are clearly inverse U-shaped: reported costs increase with GDP per capita at low incomes and then decrease, falling more steeply at high incomes. Fig. 3e illustrates for the case of corruption. Answers to the question on corruption reflect the absence of the appropriate public infrastructure to eliminate it as an obstacle to firms' activities. Recent work on corruption suggests that its control reflects a subtle relationship between the state and civil society (Aghion et al. 2009). Aghion et al. argue that individuals in low trust societies demand more regulation to control the excesses of the private sector even though this leads to more corruption. The low trust equilibrium is therefore characterized by more corruption and by demands for more government intervention. The non-linear relationship in our reported cost data may indicate that the bad equilibrium in terms of the cost that corruption imposes may be located somewhat above the bottom of the GDP per capita spectrum.

The most pronounced upward slope is for labor regulation (Fig. 3f), where reported costs rise at higher levels of GDP per capita. Labor regulation fits less easily into our model: it is a type of public infrastructure that firms deem detrimental to the operation and growth of their firm – and more detrimental at higher levels of GDP per capita. This suggests that the supply of this "onerous" public infrastructure increases with GDP per capita, presumably reflecting the increasing taste for welfare state protection as countries grow wealthier.

The relationship between reported costs of the availability of skilled labor and GDP per capita is positive, although not significantly so (Table 1). The downward sloping pattern evident for physical infrastructure (reflecting high returns from investment at low levels of income) is apparently offset in the case of human capital formation by a countervailing effect as GDP per capita rises. One interpretation of this comes from the original O-ring formulation of Kremer. In Kremer's model, workers are differentiated by skill, where their skill or quality is defined by the probability that

they make a mistake in producing a component – if they do, output falls to zero. Kremer's model produces assortative matching with workers of the same skill level matched together. This model predicts that skills are more critical in rich countries for two distinct reasons: first, in a rich country a worker who causes a component to fail because of a lack of skill throws away the value created by more highly skilled co-workers and second, because production is more complex in rich countries, a worker who makes a mistake throws away the value created by a greater *number* of co-workers.

3.7 An example: rural-urban differentials

In this sub-section, we take a stylized fact of development and test whether the survey data as interpreted through the lens of the public infrastructure / O-ring framework is consistent with it. The pattern of economic development typically displays a dualistic structure in which urban areas are the poles of development attracting labor from the rural hinterland. The dualism pattern suggests that when comparing the reported costs of public infrastructure constraints, there should be a markedly higher level of reported costs in urban as compared with rural areas in poor countries. Such a pattern would reflect the higher costs of constraints in the faster growing, more technologically advanced and therefore more infrastructure-dependent urban areas in poor countries that disappear at higher income levels. It reflects the fact that public goods are provided nationally.

Table 3 reports tests for the presence of dualism between urban and rural areas for each type of public infrastructure. These estimations are based on regressions using firm-level data with the standard set of firm characteristics as explanatory variables plus a location variable (coded so that 1=capital city through to 5=town of 50,000 population or less) that appears in both level form and interacted with country log GDP per capita and its square. The figures in the table are the predicted gaps between the least and most urbanized areas evaluated for a country with a low income per capita (US $1,000) and a country with a high income per capita (US $20,000). A negative gap indicates that rural firms report lower constraints than urban firms. The dualistic pattern is characteristic of most of the constraints: the gaps are significantly

negative at a low level of GDP per capita but not at a high level.[12] It is only in relation to physical infrastructure that there is no significant difference between rural and urban areas in low as well as in high income countries. Interestingly, the presence of more serious constraints on firm growth in urban areas in poor countries is largely absent for transition economies, which presumably reflects the inherited impact of central planners' decisions in relation to the spatial distribution of economic activity.

Table 3. Rural/urban gaps in the reported costs of constraints

Constraint	Low inc	High Inc
Average of 6 indicators	-0.182**	0.003
Infrastructure (composite)	0.112	0.098*
Telecoms	0.042	0.071
Electricity	0.169*	0.097
Transport	-0.102	0.052
Land Access	-0.162*	0.000
Skills	-0.242**	0.025
Macroeconomic Instability	-0.128	-0.001
Policy Uncertainty	-0.233**	0.074
Tax Administration	-0.211**	-0.008
Labor Regulation	-0.074	0.043
Customs	-0.313**	-0.051
Licences	-0.154*	0.011
Legal	-0.141*	-0.031
Corruption	-0.289**	-0.039
Crime	-0.220**	-0.016

Notes: The table reports predicted gaps in constraint levels between the least and most urbanized areas, evaluated at low income per capita (US $1000) and high income per capita (US $20,000). A negative gap indicates rural firms report lower constraints than urban firms. ** indicates significantly different from zero at the 1% level; * at the 5% level; tests adjusted for clustering on country.

3.8 How much of the variation in GDP per capita can be explained by institutions?

Both Hall and Jones (1999) and Acemoglu, Johnson and Robinson (2000) interpret their estimates of the role of institutional quality in economic development as a way of measuring the benefits to be expected from improving institutions. For example,

[12] As shown in Carlin and Schaffer (2010), the positive coefficient for electricity is accounted for by the low income transition economies in the sample (the coefficient is not significant for the non-transition sample). One of the legacies of transition was a higher level of physical infrastructure provision than typical of market economies at the same level of per capita GDP. This was reflected in lower reported costs of physical infrastructure constraints than in non-transition economies. For the sample of non-transition economies, the coefficient on macroeconomic instability is also negative and significant at the 1% level. For labor regulation, where the constraint is increasing in income, the phenomenon of a higher constraint in urban areas at low levels of income that disappears with development and intra-national economic integration is also observed in the non-transition sample (significant at 1%).

AJR suggest that improving Nigeria's property rights institutions to the level of Chile's would "lead to as much as a 7-fold increase in Nigeria's income", accounting for some 60% of the income gap between the two countries (p. 1371). By contrast, on the basis of their analysis of the BEEPS data (a subset of the data we use), Commander and Svejnar (2010) are sceptical of the conventional wisdom that variations in the institutional environment matter for performance. Making progress on this question is important – not least because much donor funding is conditional on improvements in the business environment. Just as the Washington consensus produced conditionality based on macroeconomic reforms, the post-Washington consensus has led to conditionality based on institutional reforms.

Our data permit a different way of quantifying the importance of institutions for country performance: motivated by the O-ring production function, we can cumulate the output losses associated with the unreliability of each of the public input constraints. We are able to overcome the curse of dimensionality by measuring directly the impact of many dimensions of public infrastructure by asking firms to rate the impact on the 1-4 scale, and then simulating the impact on sales by using the estimated relationship between answers to the question on sales lost due to electricity outages and the evaluation of the unreliability of electricity. The latter is obtained via country-specific OLS regressions in which the dependent variable is the cost, reported as a fraction of sales, of unreliable electricity supply and where the explanatory variables are the rating of electricity supply constraints on the 1-4 scale and its square. The scalings thus obtained enable us to map an obstacle on the 1-4 scale to an output index p_{ijk} where, ceteris paribus, $p_{ijk}=1$ is output of firm i in country j if a type of infrastructure k was fully reliable (rated "1 – not an obstacle"), and $p_{ijk}<1$ is output if infrastructure k was unreliable (rated 2-4). The use of country-specific scaling addresses the problems associated with variations across countries in the tendency to complain.[13] The output index incorporating the unreliability of infrastructure across

[13] The OLS regressions rescale the responses from a 1-4 to a 0-3 scale and constrain the intercept to be zero so that 0 ("not an obstacle") corresponds to a zero loss from unreliable electricity supply. The results are very similar if the original 1-4 scale is used and the constraint is not imposed, or if the same scaling is used for all countries, or if the reported obstacles are replaced with ratings adjusted for the sample composition. The effect of removing the constraint that the intercept=0 is to reduce the indices by about 10%; the relative gaps between high and low income countries as reported in Table 4, however, change very little.

multiple types of infrastructure for firm i in country j is simply $P_{ij} \equiv \prod_k p_{ijk}$, and $(1 - P_{ij})$ is a measure of the total impact of imperfect infrastructure.[14]

In Table 4, we show the impact reported by firms of the cumulated loss of output due to unreliable physical infrastructure (including access to land) and skills in column 1, institutions in column 2 and the combined set of public inputs in column 3. Countries are divided into groups according to 2004 GDP per capita using the standard World Bank classification. The simulations indicate that in high income countries, unreliable physical infrastructure and access to skills reduce output by less than 5%, whereas they reduce output by 15% in low income countries. Institutions (i.e., macroeconomic instability, tax administration, labor regulation, customs, licences, legal, corruption, and crime) have a somewhat larger impact, varying from 6% in high income countries to over 20% in low income ones. Combining both types of public infrastructure, the impact is to reduce output by 10% in high income countries and by 31% in low income ones.

Table 4. Index of output relative to the counterfactual in which public inputs are fully reliable[15]

	Physical infrastructure (including land access) & skills	Institutions (macro, tax administration, labor, customs, licensing, legal, corruption, crime)	Combined
High income	0.96	0.94	0.90
Upper-mid income	0.94	0.87	0.82
Lower-mid income	0.92	0.83	0.78
Low income	0.85	0.78	0.69
Full sample	0.91	0.84	0.78

Perhaps the most surprising single result is the scale of the impact of institutions on output and productivity. The results suggest that if institutions were transplanted from

[14] Note that this assumes that failure events are not correlated across infrastructure types; if they are positively correlated, the true output index $P_{ij}^* > \prod_k p_{ijk}$ and our calculated index P_{ij} is a lower bound, i.e., $(1 - P_{ij})$ is an upper bound on the total cost for firm i of imperfect infrastructure. This would affect the results in Table 4 only if this correlation varied with country income, and even then the main qualitative results, and in particular the relatively small gap between rich and poor countries attributable to physical infrastructure and institutions, would remain unchanged.

[15] In column 1, the sample is 28,164 firms from 57 countries, in col. 2, 46,869 firms from 69 countries; and in col. 3, 34,424 firms from 57 countries.

high income countries into low income ones, in the sense of making them as reliable in the latter countries as they are in the former, then the output of existing firms in low income countries would go up by only about 20%. As we noted earlier, it is likely that the perceptions of lost output by firm managers do not include the dynamic consequences that might flow from improved infrastructure over time and they do not take account of the impact of such improvements on new entry. Nevertheless, this exercise suggests that we should be modest about the share of GDP differences that can be attributed to institutional differences of this kind. Even if institutions broadly defined raise Chile's income by a factor of 7 as compared with Nigeria's (Acemoglu, Johnson and Robinson, 2000), improving the reliability of specific institutions as enumerated above cannot be expected to have anything like the same scale of effect.

Our results can be interpreted as complementary to those of Kremer (1993). Kremer's O-ring model with assortative matching in labor skills generates large differences in productivity across countries. Our O-ring model and data applied to infrastructure and institutions but without assortative matching in skills suggest the former account directly for modest differences in productivity across countries.

These results do not, of course, mean that the insights to be gained from these data about the relative importance of different dimensions of infrastructure improvement are inaccurate, just that we cannot look to such improvements *on their own* to make up a substantial proportion of the difference in development between rich and poor countries. This caveat should be borne in mind in interpreting the results of our case studies in the next section.

4. Using the Framework for Cross Country Comparisons of Public Infrastructure Constraints on Firm Growth

The results of Section 3 indicate that the responses of firms to the survey questions vary with firm and country characteristics in the way we would expect them to do if they indeed report an O-ring type reliability measure. We now turn to how such data can be used to uncover what the main bottlenecks to growth are in different countries. Our data allow us to identify public infrastructure bottlenecks as they affect existing firms.

Since we do not model infrastructure supply, there are limits to the extent to which policy priorities can be identified using the framework we have developed. In particular, we do not have information on the cost that would be incurred if a dimension of infrastructure were to be upgraded to the extent that it was recorded as "not an obstacle". Nevertheless as argued in Section 2, the availability of cross-country data provides a benchmark for the policy-maker to use: in relation to a particular type of infrastructure, we can see whether there is evidence that the reported cost of the constraint in country j is high relative to the predicted value for a typical country at the same level of development. If it is, it points to the need to investigate more closely whether improvement of this element of infrastructure has been neglected because it is especially costly to remedy in country j or whether this represents an unexploited social investment opportunity. At a broader level, when trying to pin down the priorities for attention across the range of types of public infrastructure, we can see which types are identified by firms as especially burdensome and how this compares with their prioritization in a typical country at the same level of GDP per capita.

To demonstrate how the framework can be used, we take three comparative case studies. In each, we choose two countries from a different region of the world. The pragmatic reason for taking each case from one region is that within a region the surveys are carried out at around the same time and using the same instrument. Our first case is from South America, where we look at Brazil and Chile. Next we compare Bangladesh and Pakistan, and the final case study is of Mozambique and Senegal.

For each country, we compute the measures that allow us to answer the four diagnostic questions introduced in Section 2. We use the country-specific average reported cost of the constraint for each constraint k and the average across all constraints ($\tilde{\tilde{ARC}}_{jk}$, $\tilde{\tilde{AKRC}}_{j}$), and the associated benchmark measures of each ($\hat{ARC}_{jk}(A_j)$, $\hat{AKRC}_{j}(A_j)$), which are the fitted values at the country of interest's GDP per capita.

The four questions are:

#1. Do firms in country j generally report themselves as more constrained than firms in a typical country? This is measured by $AK\tilde{\tilde{R}}C_j - AK\hat{R}C_j(A_j)$.

#2. Do firms in country j report that constraint k is high – a priority – compared to other constraints in that country? This is measured by $A\tilde{\tilde{R}}C_{jk} - AK\tilde{\tilde{R}}C_j$.

#3. Do firms in country j report that constraint k is high compared to how firms in a typical country report it? This is measured by $A\tilde{\tilde{R}}C_{jk} - A\hat{R}C_{jk}(A_j)$.

#4. Do firms in country j report that constraint k is high compared to other constraints, vs. how firms in a typical country report constraint k vs. other constraints? This is measured by $\left(A\tilde{\tilde{R}}C_{jk} - AK\tilde{\tilde{R}}C_j\right) - \left(A\hat{R}C_{jk}(A_j) - AK\hat{R}C_j(A_j)\right)$.[16]

4.1 Brazil and Chile

The surveys were conducted in 2003 in Brazil and 2004 in Chile and included all 14 aspects of public infrastructure. Brazil's GDP per capita at PPP is not quite 70% that of Chile. The average reported cost of infrastructure constraints on the scale from 1 (no obstacle) to 4 (major obstacle) is 2.71 for Brazil and 1.72 for Chile. The fitted values for a typical country at Brazil's GDP per capita are 2.09 and just lower at 2.04 for a comparator of Chile. This highlights the tendency for Brazilian firms to complain much more than their comparators and for Chilean firms to complain less. These differences are significant at the 1% level.

Turning to the second question, Fig. 4a shows for each country the deviation from the country's own average reported cost of constraint for each dimension of infrastructure. There is much more variability in the within-country prioritization in Brazil than in Chile. Concerns in Brazil are concentrated among the short-run

[16] The relevant definitions are as follows. The mean RC across all infrastructure types for firm i in country j is: $K\tilde{\tilde{R}}C_{ij} = \frac{1}{K}\sum_k \tilde{\tilde{RC}}_{ijk}$, which averaged across firms is $AK\tilde{\tilde{R}}C_j = \frac{1}{N}\frac{1}{K}\sum_i\sum_k \tilde{\tilde{RC}}_{ijk}$. The firm-level priority measure is $\tilde{\tilde{R}}C_{ijk} - K\tilde{\tilde{R}}C_{ij} = \tilde{\tilde{R}}C_{ijk} - \frac{1}{K}\sum_k \tilde{\tilde{RC}}_{ijk}$. The country-level priority measure is $A\tilde{\tilde{R}}C_{jk} - AK\tilde{\tilde{R}}C_j$.

macroeconomic indicators (macro stability and policy uncertainty) followed by tax administration, corruption, and labor regulation. Physical infrastructure, skills and other aspects of the institutional environment are not identified as priorities. In Chile, the variation is much less and the highest levels of concern are with the macroeconomic environment, labor regulation and skills. The policy regime is evidently viewed by firms as reliable and there are few signs of concern over physical infrastructure or the other institutional dimensions. Tests of the significance of the gaps shown in the figures are reported in Table 5.

The third question focuses on comparing evaluations in the country of interest with those of a typical country at the same GDP per capita. Fig. 4b shows the results for Brazil and Chile. The bars at the right hand end of the figure show the deviations of each country from the typical country averaged across all dimensions. Where Brazil stands out – relative to the general tendency of firms there to complain more than in comparable countries – is in relation to labor regulation, the macroeconomic environment, policy uncertainty, tax administration, corruption and crime. In Chile, it is only in relation to labor regulation that its complaint level is high as compared with a typical country at the same level of GDP per capita.

The fourth question brings together the country-specific prioritization with the cross-country benchmarking. The results are shown in Fig. 4c. Although macro and uncertainty rather than labor regulation were ranked as the highest priority by firms in Brazil, other countries also rank macro and uncertainty highly (as we saw in Fig. 3.2). This does not mean that they are not a priority for Brazil, but the benchmarking highlights the fact that concerns about labor regulation emerge as especially costly in the sense that Brazilian firms report that labor regulation is costly as compared to other constraints to a greater extent than do firms in a typical country. Fig. 4c shows that it is also labor regulation that stands out for Chile – this is not surprising because it was both the top priority identified by firms in Chile and it was also the only aspect of the business environment where Chile had a higher reported cost of constraint than in comparator countries.

4.2 Bangladesh and Pakistan

It is of interest to compare these two countries given that they became two separate countries relatively recently, in 1971. The surveys were conducted in 2002 and all elements of infrastructure were included in the survey instrument apart from the question about the functioning of the legal system. Bangladesh's GDP per capita is 50% that of Pakistan. The average fitted value of the reported cost of constraints is the same for Bangladesh and Pakistan (at 2.23): the conditional mean reported cost of constraints in Bangladesh is 2.68, clearly above the benchmark (significant at 1%)) whereas Pakistan lies virtually on the benchmark with 2.26.

A comparison between Fig. 5a and Fig. 6a shows that the within-country ranking of public infrastructure problems is very different for these poor countries as compared with the middle and high-middle income Brazil and Chile. The macroeconomic environment is not rated as important and elements of the physical infrastructure take on greater importance than was the case in Brazil or Chile. Electricity stands out as the top priority for Bangladeshi firms, with corruption and tax administration also ranked highly. Firms in Pakistan pick out the same three elements but give them a more even weighting.

As compared with a typical country at its GDP per capita, the average complaint level in Bangladesh is high (as shown by the right hand bar in Fig. 5b). Electricity and land access are rated as more problematic than elsewhere, as is corruption. For Pakistan, complaints are high relative to their comparators in relation to labor regulation, tax administration and electricity.

Fig. 5c shows that Bangladeshi firms rate land access and electricity as more important than other constraints to a greater extent than is the case in comparable countries. Although land access was not especially highly ranked by Bangladeshi firms (relative to other constraints), its unusually high weight compared with firms in a typical country with the same GDP per capita suggests that policy-makers need to try to understand why it inhibits the operation and growth of firms. Similarly, although Pakistani firms do not place labor regulation among their top-ranked constraints, its importance as an obstacle is considerably higher than is the case in other comparable countries.

4.3 Mozambique and Senegal

These two African countries were surveyed in 2007 and macroeconomic environment and policy uncertainty were omitted from the questionnaire. Mozambique is poorer than Bangladesh and Senegal is poorer than Pakistan; Mozambique's GDP per capita is about one-half that of Senegal. Both countries have average reported costs of constraints significantly (at the 1% level) below the benchmark at their levels of GDP per capita.

The within-country results are striking: in Mozambique, crime is clearly the top-ranked constraint. In Senegal, it is electricity (Fig. 6a). However as Fig. 6b illustrates, it is not just that very poor countries report high costs of unreliable electricity supply – Senegal stands out as having a serious problem relative to a typical country at its level of GDP per capita. By contrast, although electricity was Mozambique's second ranked constraint, the level of complaints about electricity there are well below those in comparable countries. Mozambique's top-ranked constraint of crime shows up as unusually high relative to comparator countries.

Fig. 6c reinforces the severity of the electricity problem for Senegal; transport also appears to require attention. Of the institutional constraints, it is licensing where the shortcomings appear more severe relative to their ranking elsewhere. In Mozambique, crime is both the top-ranked constraint by firms and more so than is typical for a country with this level of GDP per capita.

In sum, the country case studies illustrate how our framework can be used in conjunction with the survey data to inform policy-making. Priorities differ markedly across countries, and the benchmarks provide pointers that indicate the need to investigate whether the costs (monetary and or political) of remedying the infrastructure deficit are especially high in the country in question or whether there are unexploited social investment opportunities.

Figure 4. Brazil and Chile: Within and Between Country Differences in Reported Costs of Constraints

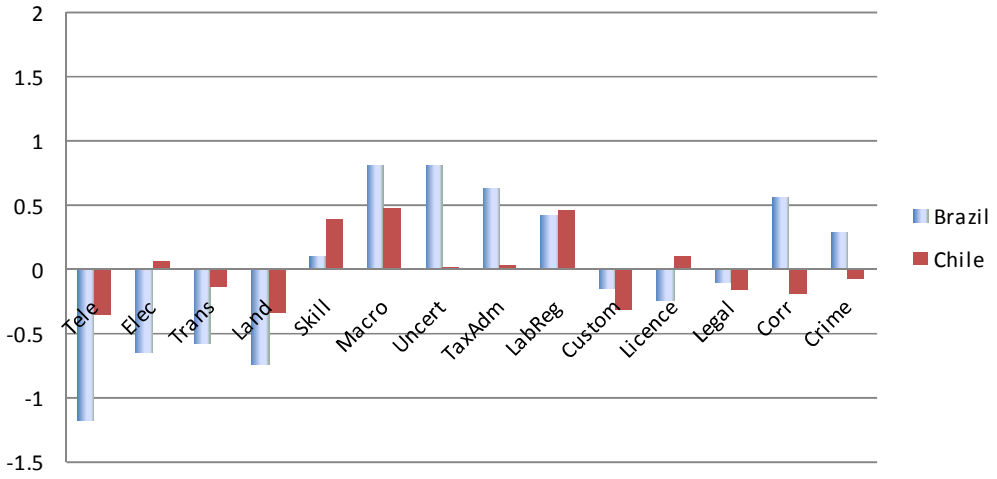


Fig. 4a. Do firms report that constraint k is high compared to other constraints in their country?

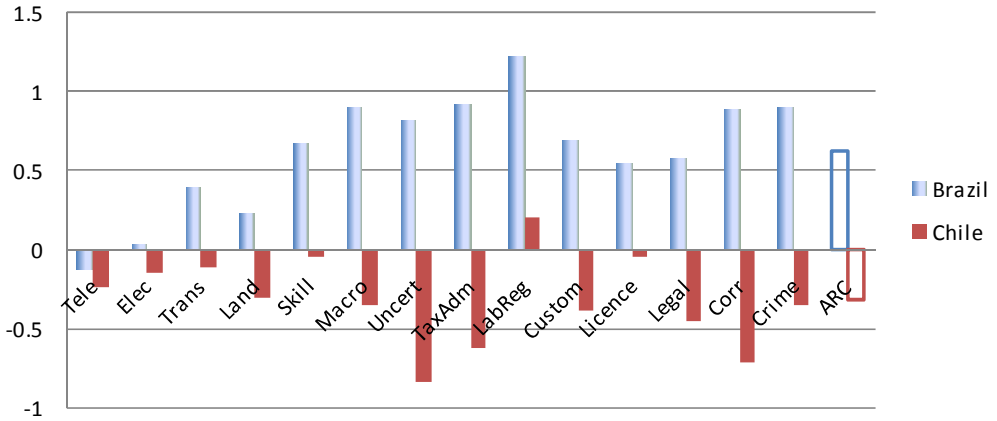


Fig. 4b. Do firms in country j report that constraint k is high compared to how firms in a typical country report it?

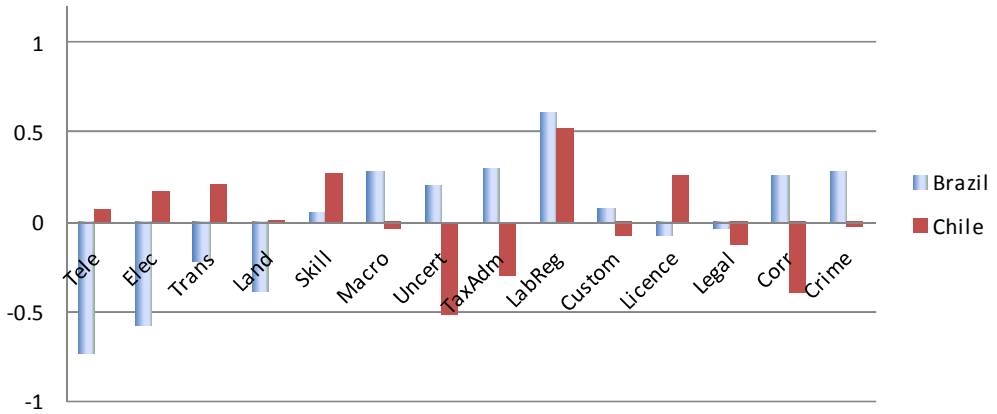


Fig. 4c. Do firms in country j report that constraint k is high compared to other constraints vs. how firms in a typical country report constraint k vs. other constraints?

Figure 5. Bangladesh and Pakistan: Within and Between Country Differences in Reported Costs of Constraints

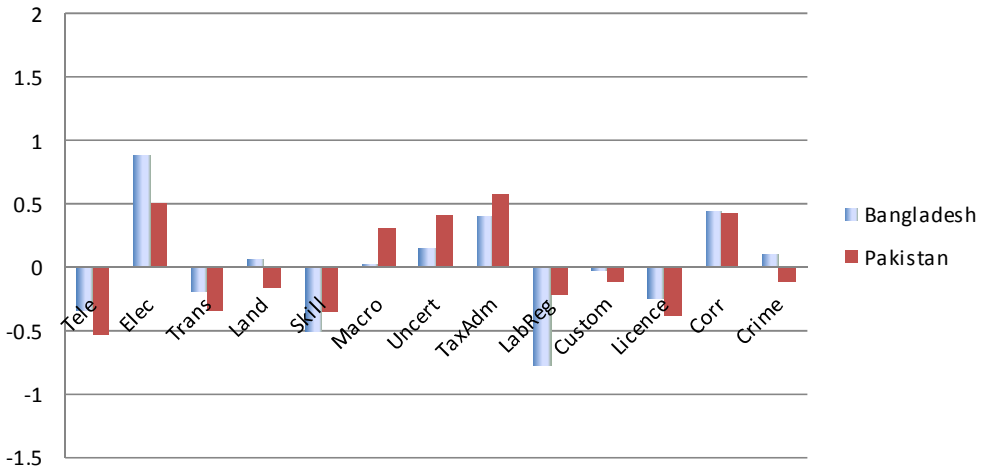


Fig. 5a. Do firms report that constraint k is high compared to other constraints in their country?

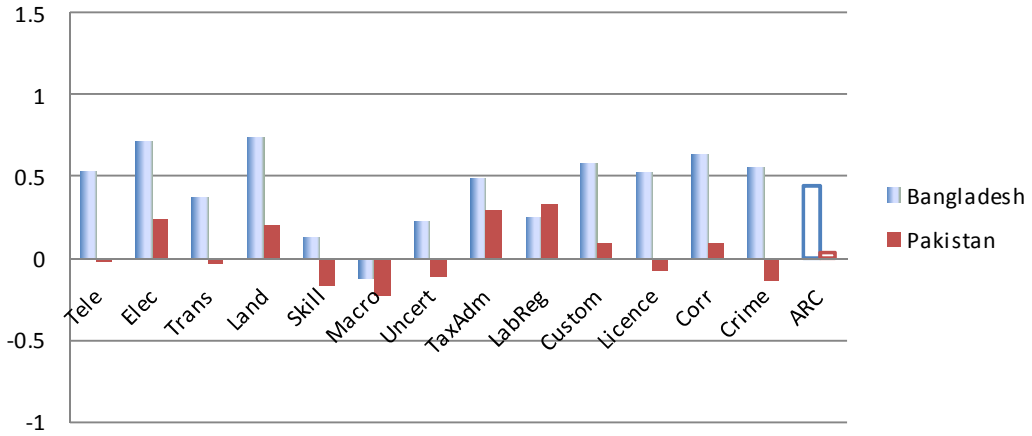


Fig. 5b. Do firms in country j report that constraint k is high compared to how firms in a typical country report it?

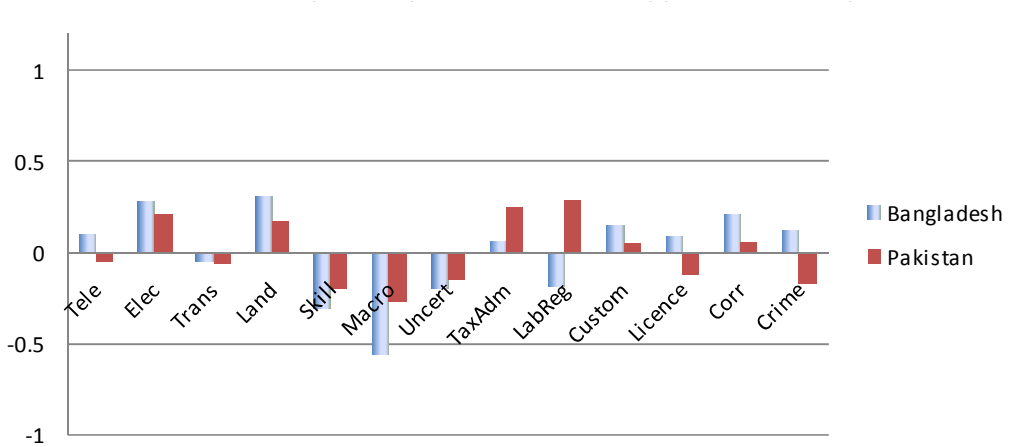


Fig. 5c. Do firms in country j report that constraint k is high compared to other constraints vs. how firms in a typical country report constraint k vs. other constraints?

Figure 6. Mozambique and Senegal: Within and Between Country Differences in Reported Costs of Constraints

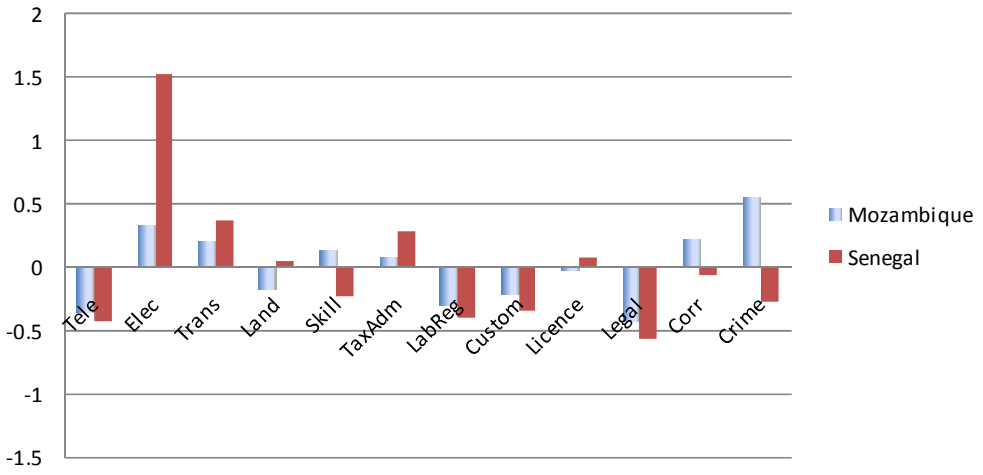


Fig. 6a. Do firms report that constraint k is high compared to other constraints in their country?

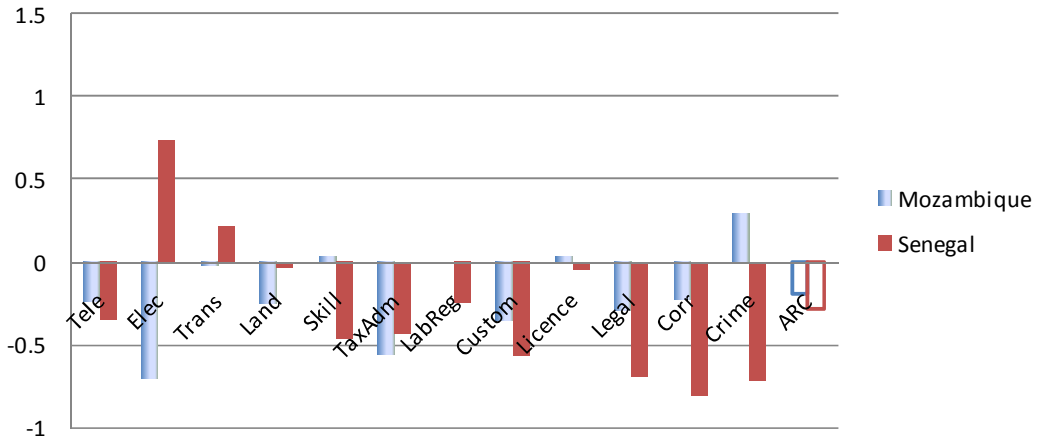


Fig. 6b. Do firms in country j report that constraint k is high compared to how firms in a typical country report it?

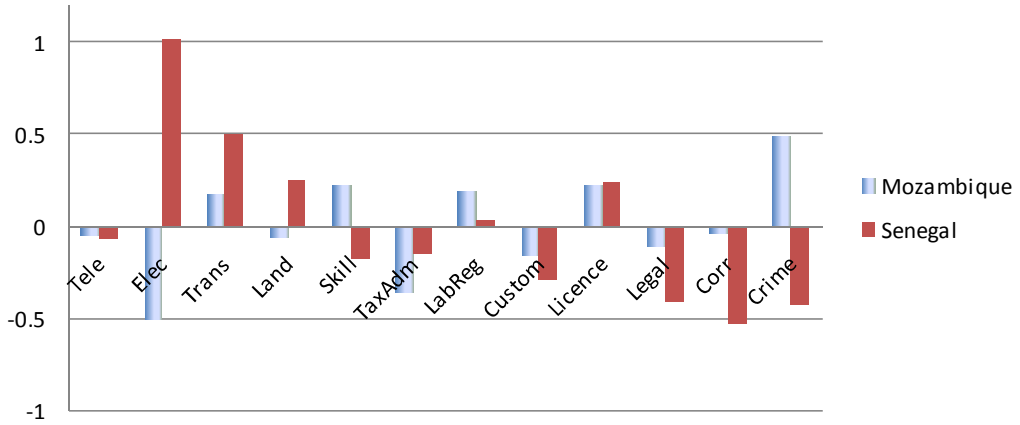


Fig. 6c. Do firms in country j report that constraint k is high compared to other constraints vs. how firms in a typical country report constraint k vs. other constraints?

Table 5. Significance tests for measures #2, #3 and #4 illustrated in Figures 5-7 for the country case studies

	Measure	Infra-structure	Telecoms	Electricity	Transport	Land Access	Skills	Macro-economic Stability	Policy Uncertainty	Tax Admin-istration	Labor Regul-ation	Customs	Licences	Legal	Corruption	Crime
Brazil	#2	-0.790**	-1.180**	-0.650**	-0.580**	-0.750**	0.100**	0.820**	0.810**	0.640**	0.420**	-0.140**	-0.240**	-0.100**	0.570**	0.280**
	#3	0.080	-0.120**	0.040	0.400**	0.230**	0.670**	0.900**	0.820**	0.920**	1.230**	0.690**	0.540**	0.580**	0.880**	0.900**
	#4	-0.540**	-0.740**	-0.580**	-0.220**	-0.390**	0.050**	0.280**	0.200**	0.300**	0.610**	0.070**	-0.080**	-0.040**	0.260**	0.280**
Chile	#2	-0.120**	-0.350**	0.060	-0.130**	-0.340**	0.390**	0.480**	0.020	0.040	0.460**	-0.320**	0.110**	-0.160**	-0.190**	-0.080**
	#3	-0.190**	-0.240**	-0.150*	-0.110*	-0.310**	-0.050	-0.350**	-0.840**	-0.620**	0.210**	-0.390**	-0.050	-0.450**	-0.720**	-0.350**
	#4	0.120**	0.070**	0.170	0.210**	0.010**	0.270**	-0.040**	-0.520**	-0.300**	0.520**	-0.080**	0.260	-0.130**	-0.400	-0.030**
Bangladesh	#2	0.140**	-0.340**	0.890**	-0.190**	0.060	-0.510**	0.020	0.150**	0.390**	-0.770**	-0.020	-0.240**		0.440**	0.110**
	#3	0.540**	0.530**	0.720**	0.380**	0.740**	0.120*	-0.120	0.230*	0.490**	0.250**	0.580**	0.520**		0.640**	0.560**
	#4	0.100**	0.100**	0.280**	-0.050**	0.310**	-0.310**	-0.560**	-0.200**	0.060**	-0.190**	0.150**	0.090**		0.210**	0.120
Pakistan	#2	-0.110**	-0.530**	0.510**	-0.340**	-0.160**	-0.360**	0.310**	0.410**	0.580**	-0.220**	-0.120**	-0.380**		0.430**	-0.120**
	#3	0.040	-0.020	0.240**	-0.030	0.200**	-0.170**	-0.230**	-0.110	0.290**	0.330**	0.090	-0.080		0.090	-0.130
	#4	0.010**	-0.050**	0.210**	-0.060**	0.170**	-0.200**	-0.270**	-0.150**	0.250**	0.290**	0.050**	-0.120**		0.060**	-0.170
Mozambique	#2	0.070*	-0.360**	0.320**	0.200**	-0.180**	0.130**			0.070	-0.300**	-0.220**	-0.020	-0.420**	0.220**	0.550**
	#3	-0.320**	-0.240**	-0.700**	-0.020	-0.250**	0.030			-0.550**	0.000	-0.350**	0.030	-0.300**	-0.230*	0.300**
	#4	-0.130**	-0.050**	-0.510**	0.170**	-0.060**	0.220			-0.360**	0.190**	-0.160**	0.220**	-0.110**	-0.040**	0.490**
Senegal	#2	0.510**	-0.420**	1.520**	0.370**	0.050	-0.230**			0.290**	-0.400**	-0.340**	0.070	-0.570**	-0.070	-0.270**
	#3	0.190**	-0.350**	0.740**	0.220**	-0.030	-0.460**			-0.430**	-0.250**	-0.570**	-0.040	-0.690**	-0.810**	-0.710**
	#4	0.470**	-0.070**	1.020**	0.500**	0.250*	-0.180**			-0.150**	0.030**	-0.290**	0.240	-0.410**	-0.530**	-0.430*

****** is significant at 1%; ** at 5%. Test are heteroskedasticity-robust Wald tests of the null hypothesis that the measure is zero.

5. Conclusions

In this paper, we have presented an analytical framework that can be used to interpret firm-level data from a wide range of countries on the reported costs of public infrastructure constraints. We derived predictions as to how the reported costs would vary within countries according to the characteristics of firms and we verified these by estimating within-country regressions using the large EBRD-World Bank firm-level survey dataset. The results confirmed that reported costs were increasing in firm size, that proxies for firm-specific productivity such as manager education were positively correlated with reported costs, and that reported costs were related to sector, ownership and exporting characteristics in the predicted manner.

We estimated cross country equations for each constraint and uncovered a variety of patterns in the income–constraint locus. For example, the divergence in economic development between urban and rural areas in poor countries was reflected in higher reported costs of constraints in urban areas in poor countries, which proxies for the technologically leading and internationally integrated sector of the economy. At high levels of GDP per capita when the national economy is integrated, the dualism between rural and urban disappears and so does the gap in the cost of constraints in the survey data.

From the cross-country equations, we obtained predicted values for the cost of each constraint reported by a benchmark firm in a typical country. This allowed us to undertake an illustrative diagnostic exercise where we uncovered whether firms in a country of interest reported that their priority constraint was high compared to how other firms in a typical country reported the priority of that element of public infrastructure. Comparisons with a benchmark country can provide the policy-maker with useful information when trying to establish the country's specific priorities. Where priorities expressed by firms look very different from those in a typical country at the same level of development, the policy maker would be led to investigate whether this may be due to especially high costs of remedying the infrastructure deficiency or country-specific reasons for a high reliance on this particular public good.

We use the framework to construct estimates of the impact of unreliable public infrastructure on output and productivity. The results suggest that if institutions were transplanted from high income countries into low income ones, in the sense of making them as reliable in the latter countries as they are in the former, then the output of existing firms in low income countries would go up by only about 20%. These estimates capture just the effect of changing the institutions when all else is held constant, including investment in physical capital and skills, new entry etc., which we would not expect to remain constant when the institutions changed. Our results therefore suggest that improving the reliability of specific institutions – from physical infrastructure to the legal system – can be expected to have relatively modest effects in the absence of substantial endogenous changes in the other important determinants of income. Research is required on whether improvements in the business environment are catalysts for the investments in technology and skills by existing firms and new entrants that are required for catching up.

The data presented here suggest that public infrastructure constraints vary in interesting and important ways with the level of development – however, it is also apparent that there is very substantial variation in country experience. The heterogeneity across countries argues for an approach to investigating the role of institutions in economic development and to establishing policy priorities for specific countries that does not assume a common technology of development. Our results indicate that priorities vary widely among countries and suggest a degree of caution about donor policies tying development assistance to generic improvements in the business environment. Such improvements are not always easy to achieve and may have more modest direct benefits than has previously been believed. In contrast, using these results to identify particularly important constraints on output in specific countries may be very useful to policymakers.

References

Acemoglu, D., Johnson, S. and Robinson, J. A. (2001) 'The Colonial Origins of Comparative Development: An Empirical Investigation'. *The American Economic Review,* Volume 91, Number 5

Aghion, P., Fally, T. and Scarpetta, S. (2007). 'Credit constraints as a barrier to the entry and post-entry growth of firms'. *Economic Policy*. 22, 52: 731-779.

Aghion, P., Algan, Y., Cahuc, P., Shleifer, A. (2009) 'Regulation and distrust', NBER Working Paper 14648 http://www.nber.org/papers/w14648

Atkinson, A.B. and Stiglitz, J.E. (1980). *Lectures in Public Economics* London: McGraw-Hill

Beck, T., Demirguc-Kunt, A. and Maksimovic, V. (2005). Financial and Legal Constraints to Firm Growth: Does Size Matter? *Journal of Finance* 60, 137-178.

Carlin, W., Schaffer, M. and Seabright, P. (2007). 'What are the Real Bottlenecks? Evidence from 20,000 firms in 60 countries about the shadow costs of constraints to firm performance', IZA Discussion Paper 3059.

Carlin, W. and Schaffer, M. (2010). 'Public infrastructure constraints on growth in the transition economies: the legacy of communism and evidence from enterprise surveys 1999-2008'. Discussion Paper, forthcoming.

Carlin, W. and Seabright, P. (2009) 'Bring Me Sunshine: Which Parts of the Business Climate Should Public Policy Try to Fix?', in J. Lin and B. Pleskovic (Ed.) Annual Bank Conference on Development Economics: Private Sector and Development. Washington D.C. : World Bank.

Collier, P. (2007). *The Bottom Billion: Why the poorest countries are failing and what can be done about it*. Oxford: OUP.

Commander, S. and J. Svejnar. (2010). 'Do Institutions, Ownership, Exporting and Competition Explain Firm Performance?' *Review of Economics and Statistics*, forthcoming.

Deaton, A. (2009) 'Instruments of Development: Randomization in the Tropics and the Search for the Elusive Keys to Economic Development'. NBER Working Paper 14690.

Dollar, D., Hallward-Driemeier, M. and Mengistae, T. (2005). 'Investment Climate and Firm Performance in Developing Economies' *Economic Development and Cultural Change* vol.54, no.1: 1-31.

Dixit, A. (2007). 'Evaluating Recipes for Development Success', *The World Bank Research Observer*, vol. 22, no. 2 (Fall 2007).

Hallward-Driemeier, M. and Aterido, R. (2009). 'Comparing Apples with…Apples: How to Make (More) Sense of Subjective Rankings of Constraints to Business' World Bank Policy Research Working Paper 5054

Hausmann, R., Rodrik, D. and Velasco, A. (2006). 'Growth Diagnostics' in *Finance and Development* 43 (1). and in N. Serra and J. Stiglitz (ed.) (2008). *The Washington Consensus Reconsidered: Towards a New Global Governance* Oxford: OUP.

Horowitz, J. (2004). 'Statistical Issues in the Evaluation of the Effects of Right-to-Carry Laws'. in C. F. Wellford, J. V. Pepper and C. V. Petrie (eds) *Firearms and Violence: A Critical Review* Washington D.C.: National Academies Press

Kremer, M. (1993). 'The O-ring Theory of Economic Development'. *Quarterly Journal of Economics* 108: 551-575

Rajan, R. G. and Zingales, L. (1998). 'Financial Dependence and Growth'. *American Economic Review* 88: 559-586.

Stinchcombe, Arthur L. and Harris, T. Robert, 'Interdependence and Inequality: A Specification of the Davis-Moore Theory', *Sociometry*, Vol. 32, No. 1 (Mar., 1969), pp. 13-23.

Data Appendix

The full dataset available to us covers over 81 thousand firms. The data originate in a series of 206 different surveys conducted in 103 countries over the period 1999-2009. There are two different survey series: BEEPS (Business Environment and Economic Performance Survey), conducted by EBRD and the World Bank and covering mostly transition countries, and PICS (Productivity and Investment Climate Survey), conducted by the World Bank and covering both transition and non-transition countries. The BEEPS and PICS surveys are based on random samples of non-agricultural firms, usually stratified on size, sector and ownership. Most of the firms in the surveys are small or medium-sized enterprises (SMEs): median employment in the total sample is 27, and about 90% of the sample have fewer than 300 employees.

Table A.1 below reports the numbers of survey, countries and firms, by business environment constraint; the numbers vary because different surveys included some business constraint questions and omitted others. The (a) and (b) columns refer, respectively, to the numbers of surveys, countries and firms for which we have data on constraints, and of those, where we also have data on the firm characteristics used in the firm-level econometric analysis.

Table A.1: Data coverage of surveys, countries and firms

	Surveys		Countries		Firms	
	(a)	(b)	(a)	(b)	(a)	(b)
All	206	197	103	95	81,433	72,145
Infrastructure (composite)	203	195	101	94	62,644	55,984
Telecoms	179	171	102	95	59,595	53,042
Electricity	180	171	103	95	76,375	67,511
Transport	179	170	102	94	75,360	66,638
Land Access	177	171	100	95	72,616	64,754
Skills	177	171	100	95	75,347	67,074
Macroeconomic Instability	167	162	96	92	64,963	58,891
Policy Uncertainty	136	135	74	74	49,817	45,897
Tax Administration	201	195	100	95	78,611	70,565
Labour Regulation	201	195	100	95	78,441	70,392
Customs	204	196	102	95	72,437	64,930
Licences	201	195	100	95	77,169	69,272
Legal	186	180	88	83	65,014	58,781
Corruption	202	196	101	95	76,871	68,982
Crime	200	193	98	92	76,626	68,092

Table A.2 reports the means of these firm characteristics. The figures cover the 72,145 firms for which we have observations on all characteristics. The exception is employment, which was not available for 3,844 firms in the 1999 BEEPS survey. For these firms, a categorical variable for numbers of employees was available. We imputed log employment for these firms by assigning them the mean log employment for firms in the same size categories in the BEEPS 2002-05 surveys.

Total employment includes permanent plus temporary (if reported separately). Expanding and contracting firms are those that reported increases or decreases in the numbers of permanent employees 2 or 3 years previously (depending on data availability). We used dummies for both majority state ownership (including 100% state-owned) and 100% state-owned because some surveys excluded 100% state-owned firms (but allowed 50-99% state-owned).

Table A.2: Firm characteristics

	Mean
Total employment (median)	27
Log employment	3.52
Log employment (incl. imputed)	3.53
Expanding firms	46.9%
Contracting firms	24.8%
(No change)	28.3%
Services	27.6%
Construction	5.6%
(Manufacturing)	66.8%
Privatized	8.2%
State-owned (≥50%)	5.1%
State-owned (100%)	3.8%
Foreign-owned (≥10%)	12.1%
Exporter (≥10% of sales)	18.4%

Table A.3 reports the survey coverage by country and year. The cells report the number of firms that responded to one or more business constraint questions, and, in brackets, the number of firms that also provided data on the firm-level characteristics in Table A.2. In Turkey in 2005, there were two separate surveys conducted; the table reports aggregate figures for these two surveys.

Country income group classifications are from the World Bank World Development Indicators 2005 except for Kosovo, which was unlisted and is given the same classification as Serbia and Montenegro.

The data on GDP at PPP used in the analysis (not reported here) are from the World Bank World Development Indicators 2009, except for: (1) Kosovo, which is set to 85% of Serbian level, based on 1998 data for the average wage from the Yugoslav Statistical Pocketbook 2001; (2) Serbia-Montenegro, which is a weighted average of Serbia and Montenegro GDP at PPP using 1998 population weights. For all countries, 2008-09 GDP at PPP were not available and so we used 2007 figures in their place.

Table A.3: Survey coverage by country and year

Country	World Bank classification (2004)	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Albania	Lower-middle	163 (101)			170 (164)			203 (198)		121 (88)	54 (45)	
Algeria	Lower-middle				549 (511)							
Angola	Lower-middle								425 (275)			
Argentina	Upper-middle								1063 (955)			
Armenia	Lower-middle	125 (116)			171 (167)			349 (345)			252 (187)	122 (82)
Azerbaijan	Lower-middle	137 (130)			168 (157)			349 (345)			356 (314)	24 (21)
Bangladesh	Low				1000 (966)							
Belarus	Lower-middle	132 (128)			250 (250)			324 (323)			273 (231)	
Benin	Low						197 (181)					
Bhutan	Low			93 (0)								
BiH	Lower-middle	192 (183)			178 (165)			196 (190)			347 (310)	14 (14)
Bolivia	Lower-middle								613 (558)			
Botswana	Upper-middle								342 (259)			
Brazil	Lower-middle					1641 (1599)						
Bulgaria	Lower-middle	130 (126)			250 (241)		548 (0)	299 (286)			288 (267)	
Burkina Faso	Low								139 (0)			
Burundi	Low								270 (216)			
Cambodia	Low					503 (479)						
Cameroon	Low								172 (0)			
Cape Verde	Lower-middle								98 (0)			
Chile	Upper-middle						948 (944)		1017 (963)			
China	Lower-middle				1500 (1448)							
Colombia	Lower-middle								1000 (936)			
Congo, Dem. Rep.	Low								340 (271)			
Costa Rica	Upper-middle							343 (333)				
Croatia	Upper-middle	127 (115)			187 (168)			235 (222)		56 (52)	55 (54)	49 (49)
Czech Republic	Upper-middle	149 (140)			266 (254)			342 (324)			80 (62)	170 (140)

Country	World Bank classification (2004)	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Ecuador	Lower-middle					453 (416)			658 (594)			
Egypt, Arab Rep.	Lower-middle						977 (951)					
El Salvador	Lower-middle					465 (459)			693 (621)			
Eritrea	Low				79 (79)							
Estonia	Upper-middle	132 (119)			169 (155)			216 (206)			273 (253)	
Ethiopia	Low				424 (342)							
FYR Macedonia	Lower-middle	136 (129)			168 (161)			195 (187)			361 (311)	5 (5)
Gambia	Low								174 (127)			
Georgia	Lower-middle	129 (128)			174 (172)			199 (198)			373 (287)	
Germany	High						1196 (1185)					
Ghana	Low									494 (437)		
Greece	High						541 (532)					
Guatemala	Lower-middle					455 (451)			522 (499)			
Guinea	Low								223 (182)			
Guinea-Bissau	Low								159 (135)			
Guyana	Lower-middle						163 (152)					
Honduras	Lower-middle					450 (436)			436 (421)			
Hungary	Upper-middle	147 (137)			250 (240)			608 (595)			289 (275)	2 (2)
India	Low				1824 (969)							
Indonesia	Lower-middle					713 (709)						
Ireland	High							501 (493)				
Kazakhstan	Lower-middle	147 (143)			249 (240)			584 (569)			474 (394)	70 (61)
Kenya	Low					277 (209)						
Korea, Rep.	High						598 (584)					
Kosovo	Lower-middle					328 (292)					246 (225)	24 (24)
Kyrgyzstan	Low	132 (123)			173 (163)	102 (102)		202 (192)			179 (170)	56 (50)
Latvia	Upper-middle	166 (146)			176 (167)			204 (199)			271 (237)	
Lithuania	Upper-middle	112 (108)			200 (189)		239 (221)	204 (192)			159 (143)	117 (97)
Madagascar	Low							293 (266)				
Malawi	Low							159 (150)				

Country	World Bank classification (2004)	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Mali	Low					154 (122)						
Mauritania	Low								237 (205)			
Mauritius	Upper-middle							205 (158)				
Mexico	Upper-middle								1480 (1345)			
Moldova	Low	139 (129)			174 (173)	103 (103)		349 (345)			304 (276)	59 (50)
Mongolia	Low										215 (206)	147 (143)
Montenegro	Lower-middle					100 (100)					92 (82)	28 (24)
Morocco	Lower-middle		595 (494)				850 (823)					
Mozambique	Low			189 (134)						479 (426)		
Namibia	Lower-middle								329 (243)			
Nepal	Low		223 (0)									
Nicaragua	Low					452 (448)			478 (465)			
Niger	Low							125 (0)				
Nigeria	Low			232 (0)								
Oman	Upper-middle					337 (302)						
Pakistan	Low				965 (894)							
Panama	Upper-middle								604 (551)			
Paraguay	Lower-middle								632 (603)			
Peru	Lower-middle				576 (116)				613 (564)			
Philippines	Lower-middle					688 (613)						
Poland	Upper-middle	246 (237)			500 (494)	108 (105)		975 (969)			185 (164)	270 (188)
Portugal	High						493 (490)					
Romania	Lower-middle	125 (124)			254 (252)			597 (583)			540 (446)	
Russia	Upper-middle	552 (528)			505 (486)			597 (578)			641 (573)	363 (316)
Rwanda	Low								212 (155)			
Senegal	Low					262 (213)				506 (415)		
Serbia	Lower-middle			402 (401)		408 (399)					388 (352)	
Serbia-Montenegro	Lower-middle				247 (234)			299 (288)				
Slovakia	Upper-middle	138 (128)			169 (158)			220 (208)			266 (208)	9 (9)
Slovenia	High	125 (122)			188 (183)			223 (219)			153 (137)	123 (115)

Country	World Bank classification (2004)	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
South Africa	Upper-middle					603 (541)						
Spain	High							604 (598)				
Sri Lanka	Lower-middle						450 (410)					
Swaziland	Lower-middle								307 (208)			
Syrian Arab Rep.	Lower-middle					560 (462)						
Tajikistan	Low				176 (168)	107 (107)		200 (193)			360 (268)	
Tanzania	Low					272 (243)			419 (360)			
Thailand	Lower-middle						1385 (1384)					
Turkey	Upper-middle	149 (138)			513 (504)			1874 (1773)			1152 (903)	
Uganda	Low					300 (291)			563 (509)			
Ukraine	Lower-middle	247 (241)			462 (453)			593 (583)			851 (731)	
Uruguay	Upper-middle								621 (547)			
Uzbekistan	Low	126 (125)			258 (248)	100 (100)		296 (289)			366 (325)	
Venezuela	Upper-middle								500 (0)			
Vietnam	Low						500 (498)	1149 (1108)				
Zambia	Low				207 (169)							