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Abstract

In this paper, we examine how firm-level productivity growth is dependent on a broad range of institutional quality measures at the country level. Using a sample of 3,446 firms in 58 advanced and emerging economies, we show that such institutions exert a statistically and economically significant effect on changes in firm TFP. We utilize data envelopment analysis to construct firm-level measures of Malmquist productivity, which we then condition on a range of country-level institutions, using both a full set of fixed effects and system generalized method of moments to address potential endogeneity concerns. The baseline effect is robust to alternative measures of institutions, variations in model specification, alternative temporal aggregations, and the inclusion of external instruments. Additional decompositions further reveal that the institutional effect operates via improved productive efficiency (rather than technological progress), and that the key institutions are those associated with rule of law and regulatory quality.

Keywords: firm-level TFP, Malmquist productivity, institutions, data envelopment analysis
JEL Classification: E21, E22, E02

1 Introduction

In the late morning of December 17, 2010, Mohamed Bouazizi, a street vendor in Tunisia, doused himself with gasoline and set himself alight. The proximate cause of his decision was his harassment by a local municipal inspector, Faida Hamdi, for his failure to secure a permit to sell his wares. Bouazizi's self-immolation would serve as the catalyst for the series of revolutionary protests, riots, and civil wars known as the Arab Spring.

Half a world away that same month, the Brazilian legislature was signing into law four new pieces of legislation that ceded more control of the petroleum company, Petrobras, to the state. Those actions would set in motion a series of corrupt dealings, where corporate executives and government officials would scheme to award Petrobas contracts to linked firms at inflated prices; by 2015, the investigation over these dealings would reach into the highest levels of government, ultimately leading to the impeachment of the president, Dilma Rousseff.

The perverse business operations uncovered by the Petrobas scandal was by no means unique to Latin America. An ocean away in China, poorly-run, debt-ridden state-owned enterprises (SOEs) are now regarded as a major reason behind the economy's slowdown. Gross profit growth among SOEs have stagnated since 2010, despite rising assets (Wildau 2016); yet debates over improving business practices at Chinese SOEs are essentially clouded by the often contradictory objectives—ranging from maximizing employment opportunities to promoting social targets—that the bureaucratic administrators of SOEs are forced to confront.

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What is common among these events is how each country's institutional environment—endemic corruption in Brazil, regulatory red tape in Tunisia, and ineffectual governance in China—clearly conditions the conduct and productivity of business operations, from the smallest independent firms (Bouzazi's streetside stand) to the largest state-owned entities (Petrobas), and everything in between (the estimated 144,700 state-owned enterprises in China). In this paper, we take this effect seriously, and ask how different aspects of the political-institutional environment alters a given firm's distance to the estimated production possibility frontier and, by implication, the efficiency of their production processes. This question—which is interesting in its own right—has become even more urgent, in light of the global slowdown in economic activity, and how this slowdown has been largely attributable to a significant loss of productivity (Teulings & Baldwin 2014).

Our analytical approach is a two-stage exercise: we first apply data envelopment analysis (DEA) (Charnes, Cooper & Rhodes 1978) to compute the distance of each firm to its sector-specific production frontier, before computing the corresponding (Malmquist) total factor productivity (TFP) indexes (Caves, Christensen & Diewert 1982; Färe, Grosskopf, Norris & Zhang 1994b). We then utilize the resulting indexes as our dependent variable of interest, and generate dynamic panel estimates of the effect of institutional variables on productivity using generalized method of moments (GMM) (Arellano & Bover 1995; Blundell & Bond 1998). The productivity measures are computed using a large cross-country panel dataset of publicly-listed firms drawn from the Worldscope database; we then merge these with country-level measures of political-economic institutions from various sources, including the World Bank's Worldwide Governance Indicators and Doing Business databases. Our working sample comprises 3,446 firms distributed across 58 developed (DM) and emerging (EM) market economies.

We find that institutional quality plays a statistically and economically important role in inducing changes in firm productivity. Our preferred baseline result suggests that a one-unit improvement in state governance institutions—equivalent to about a 0.4 standard deviation change relative to the mean—will see the average firm experience an increase in its TFP of 0.17 percent on the Malmquist index, which is several times greater than any of the firm covariates we examine, and comparable to the effect of changes to a country's level of development.

We also elaborate on our baseline findings in a number of ways. Decompositions of TFP reveals that the effect of institutions operates via productive efficiency, rather than technological progress; institutions also appear to operate on firms' fixed factors, in particular via the solvency and profitability channels. When we unbundle these institutions, we find that those associated with rule of law and regulatory quality are those that matter most. Indeed, the effect of such state-level institutions even dominates the mechanisms of corporate governance.

In some ways, the question posed by this paper is not fundamentally new. A voluminous literature has argued that institutional quality lies at the core of differences in economic performance between countries (Acemoğlu, Johnson & Robinson 2005; North 1990; Rodrik, Subramanian & Trebbi 2004). An equally large literature argues that cross-country variations in growth and output are attributable to productivity differences (Caselli 2005; Hsieh & Klenow 2010). Yet there is relatively little work that draws a direct connection between these two compelling strands of evidence into a single narrative,[2] and just as important, there is little work that explores the question using cross-country data from a *firm*-level perspective, where domestic institutional quality is allowed to systematically influence the manner by which firms seek to improve the efficiency of their business functioning.

Our first, and primary, contribution is drawing this simple but important distinction between corporate and national TFP. Distinguishing firm-level productivity from aggregate national productivity is important, because effects observed at the aggregate level may be misattributed to productivity, when they may instead be factors related to unobserved national attributes, such as infrastructure or favorable terms of trade. By focusing on firm-level TFP, our study minimizes such measurement-error concerns

[2]Much of the cross-country growth literature does, of course, suggest link between aggregate productivity and institutions—see, for example, Hall & Jones (1999) and Rivera-Batiz (2002)—and several papers in the literature on firm productivity—such as Scarpetta, Hemmings, Tressel & Woo (2002) and Syverson (2011)—have also pointed to the importance of the institutional environment. But these are typically indirect allusions to a relationship, as opposed to the direct connection that we draw (and test) between the two.

associated with more aggregate measures.[3] Furthermore, our reliance on Malmquist TFP measures allows us to decompose productivity into changes in technology versus efficiency, which provides additional insight into how institutions affect productivity.

Second, by relying on a large, cross-country dataset, we are able to exploit the much broader cross-sectional variation in institutional quality and productive capacity that is otherwise unavailable with time-series studies based on a single country (or small number of relatively heterogeneous economies). But doing so brings along empirical challenges of its own. A central concern is the significant heterogeneity in technical capacity and productive efficiency that underlies observed differences in productivity—both between economies (Caselli 2005; Davis & Weinstein 2001) and between firms within a country (Griliches & Mairesse 1998; Hsieh & Klenow 2009; Melitz 2003)—which manifests itself as significant variation in estimates of firm-level productivity relative to the frontier (McGowan, Andrews, Criscuolo & Nicoletti 2015). Even with technological diffusion (Comin, Hobijn & Rovito 2008), it is clear that such inherent variations in baseline productivity need to be taken into account in any empirical study that utilizes international, multi-sectoral firm data. Our appeal to nonparametric DEA-based Malquist indexes enables us to establish sector- and period-specific production frontiers, which is ideal in the presence of severe heterogeneity (van Biesebroeck 2007), while remaining agnostic about the specific functional form required for production embodied within each sector. Moreover, by allowing the production possibilities frontier to shift periodically, we further capture the possibility of exogenous or endogenous advances (or regressions) in the technological frontier. Our approach thus enables much more precise estimates of productivity that simultaneously accounts for reasonable baseline variations.

Our methodology also embeds a number of technical innovations, which help address a number of other empirical concerns. Since aggregate productivity is both unobserved[4] and potentially affected by institutional quality, studies have to contend with an endogeneity problem in measuring the effect of institutions. We circumvent this problem by imposing *country-level* measures of institutions, but relying on *firm-level* estimates of productivity. As the overall economywide institutional environment is, by and large, external to the firm, we can more confidently rule out endogeneity that arises from reverse causality. To mop up any additional effects resulting from omitted confounding variables, our second-stage specifications include the full complement of firm, industry, and year fixed effects. Finally, our estimation of institutional effects employs system GMM techniques that provide some additional control of endogeneity, using both internal and external instruments.

Although we regard our study as novel in many aspects, we nevertheless stand on the shoulders of several important strands in the literature. There are a small number of papers that have explored how institutional factors affect firm efficiency and productivity: these include the trading regime (Bernard, Jensen, Redding & Schott 2012; Liu, Siler, Wang & Wei 2000), bureaucratic and regulatory quality (Augier, Dovis & Gasiorek 2012; Nicoletti & Scarpetta 2003; Scarpetta *et al.* 2002), property rights (Anderson & Lueck 1992; Banerjee & Iyer 2005; Galiani & Schargrodsky 2011; Grafton, Squires & Fox 2000), labor market flexibility (Haltiwanger, Scarpetta & Schweiger 2014; Petrin & Sivadasan 2013), and corruption (Cai, Fang & Xu 2011; Olney 2016). However, the institutional settings explored in these papers are usually limited to one or two aspects, with little analysis of the broader framework that characterizes governance institutions or the business climate, which is our main concern.

Moreover, much of the literature is comprised of studies that are limited in their coverage in some way: many papers explore only firms located in advanced industrialized economies (Anderson & Lueck 1992; Keller & Yeaple 2009; Köke & Renneboog 2005; Nicoletti & Scarpetta 2003; Scarpetta *et al.* 2002; Syverson 2004), and those that include developing countries generally focus on either one (Augier *et al.* 2012; Cai *et al.* 2011; Muendler 2004; Pavcnik 2002) or a small handful of countries (Dollar, Hallward-Driemeier & Mengistae 2005; Hsieh & Klenow 2009), or are restricted to a single geographic region (Anós-Casero & Udomsaph 2009; Arnold, Mattoo & Narciso 2008; Eifert, Gelb & Ramachandran 2008;

[3]Of course, mismeasurement due to omitted inputs may still be present for firm-level measures. However, these are less likely to be systemic in nature, so long as the omitted variables are randomly distributed, which is more plausible at the firm than the country level.

[4]The most common measure of economywide productivity is measured as the Solow (1956) residual of a growth accounting exercise (Barro 1999), and is *assumed* to capture only advances in technology, with no room for possible inefficiency.

Petrin & Sivadasan 2013) or multinational firm (Mefford 1986). For the two studies of which we are aware that considers productivity performance and whose coverage includes a broad diversity of firms (Harrison, Lin & Xu 2014; Meyer & Evis 2009), the methodologies employed establishes only broad institutional *correlates* of firm performance, with less intent on identifying (as we do) the potential causal influence of such institutional mechanisms.

The rest of the paper is organized as follows. The next section sketches the theoretical background (section 2), while the subsequent one details the empirical methodology (section 3). Section 4 reports our baseline results, and section 5 subjects this baseline to a battery of robustness checks. A final section concludes with some thoughts on implications for business practices.

2 Theoretical Background

To fix ideas, we sketch here a stylized model of firm production that we use to motivate our estimates of Malmquist productivity via DEA; a slightly more generalized and detailed treatment, including the key assumptions underlying our application, is provided in appendix A.3.

Consider a global economy comprising $h = 1, \ldots, H$ countries and $g = 1, \ldots, G$ sectors, with each sector populated by $f = 1, \ldots, F_g$ firms, each producing output y, and using as variable factor inputs capital k and labor l. Time is the sequence $t = \{1, \ldots, T\}$. The sector-specific technology $P(k, l; y)$ is represented, for any given firm f in sector g of country h at time t, by a standard Cobb-Douglas production function

$$y_{fgh,t} = A_{fgh,t} \cdot k_{fgh,t}^{\alpha} l_{fgh,t}^{1-\alpha}, \tag{1}$$

where A is the traditional Solow (1956) residual measure of TFP, measured at the firm level, and $0 \leq \alpha \leq 1$ is capital's factor share. Firm TFP is, in turn, a persistent process that is also affected by fixed factors:

$$A_{fgh,t+1} = A_{fgh,t} \cdot \exp\left(\prod_{q=1}^{Q}\prod_{r=1}^{R} C_{q,h,t}^{\beta_q} \cdot D_{r,f,t}^{\delta_r}\right) \quad \beta_q, \delta_r \geq 0, \tag{2}$$

where $C \in \Re_Q^+$ and $D \in \Re_R^+$ are the set of country- and firm-specific factors that condition firm productivity. Importantly, the set of country factors includes, *inter alia*, measures of institutional quality.

Rearranging and taking logarithms, we obtain

$$\Delta TFP_{fgh,t+1} \approx \ln\left(\frac{A_{fgh,t+1}}{A_{fgh,t}}\right) = \prod_{q=1}^{Q}\prod_{r=1}^{R} C_{q,h,t}^{\beta_q} \cdot D_{r,f,t}^{\delta_r},$$

which states that the growth in TFP depends on fixed firm and country factors.

We next define Farrell (1957) input efficiency as the minimum contraction of the vector of inputs $\{k, l\}$ by a scalar, θ, while remaining on the technological boundary:

$$\begin{aligned} E_{fgh,t}\left(k_{fgh,t}, l_{fgh,t}, y_{fgh,t}\right) &= \inf_{\theta}\left\{\theta^{-1} : y_{fgh,t} \leq \theta A_{fgh,t} k_{fgh,t}^{\alpha} l_{fgh,t}^{1-\alpha}\right\} \\ &= \frac{\hat{y}_{fgh,t}}{A_{fgh,t} k_{fgh,t}^{\alpha} l_{fgh,t}^{1-\alpha}}, \end{aligned} \tag{3}$$

where $\hat{y}$ is the production frontier. The (input-based) Malmquist productivity index for firm f is defined as the ratio of the next-period distance to the current (base) period (Caves *et al.* 1982):

$$M_t\left(k_{fgh,t}, l_{fgh,t}, k_{h,t+1}, l_{fgh,t+1}; y_{fgh,t}, y_{fgh,t+1}\right) = \frac{E_t\left(k_{fgh,t+1}, l_{fgh,t+1}; y_{fgh,t+1}\right)}{E_t\left(k_{fgh,t}, l_{fgh,t}; y_{fgh,t}\right)}. \tag{4}$$

To avoid the arbitrary selection of a base year, take the geometric mean of the index evaluated at either base year to obtain the change in productivity given by

$$\overline{M}(t, t+1) = \left(M_t \cdot M_{t+1}\right)^{\frac{1}{2}}, \tag{5}$$

By evaluating the distance (3) for all firms, and substituting back into (5), we find

$$\begin{aligned}\overline{M}(t,t+1) &= \frac{k^{\alpha}_{fgh,t} l^{1-\alpha}_{fgh,t}}{\hat{y}_{fgh,t}} \cdot \frac{\hat{y}_{fgh,t+1}}{k^{\alpha}_{fgh,t+1} l^{1-\alpha}_{h,t+1}} \\ &= \frac{A_{fgh,t+1}}{A_{fgh,t}},\end{aligned}$$

where the second step uses the definition (1). What this demonstrates is that by using the solution to (3) in (5), the Malmquist index is equivalent to the ratio of TFP (for Cobb-Douglas production).[5]

By further taking logarithms of this expression, (5) and (2) imply that productivity growth for any given firm is a function of firm and country-specific factors:

$$\Delta TFP_{fgh,t+1} = \ln \overline{M}(t,t+1) = \prod_{q=1}^{Q} \prod_{r=1}^{R} C^{\beta_q}_{q,h,t} \cdot D^{\delta_r}_{r,f,t}, \quad \beta_q, \delta_r \geq 0. \tag{6}$$

Although—subject to the conditions, such as constant returns, that we impose here[6]—there is an equivalence between measures of TFP changes using either a growth accounting or Malmquist index approach, there are distinct advantages to our reliance on the latter. Malmquist indexes can more easily accommodate heterogeneities in firms' existing position relative to a global technology frontier (van Biesebroeck 2007), while also permitting incremental shifts in this frontier.

Malmquist measures of TFP changes are also amenable to decompositions that attribute TFP changes to either technical progress or productive efficiency:

$$\overline{M} = \Delta Tech \cdot \Delta Eff,$$

where $\Delta Tech$ and ΔEff are the (input-based) changes in technology and efficiency, respectively. Not only does this allow for the possibility of inefficiency in production—a routine occurrence, especially in developing countries (Hsieh & Klenow 2009; McMillan & Rodrik 2011)—the decomposition permits additional inference regarding whether it is one or the other that is affected by environmental factors of interest.

If we are willing to relax the assumption of constant returns,[7] the latter term can be further decomposed into efficiency changes due to scale effects, or pure efficiency:

$$\overline{M} = \Delta Tech \cdot (\Delta Pure \cdot \Delta Scale),$$

where $\Delta Pure$ and $\Delta Scale$ are, respectively, changes in efficiency due to pure efficiency gains and economies of scale, respectively.

In addition to offering a clean decomposition of productivity into technical versus efficiency changes, representing TFP changes via Malmquist indexes allows us to evaluate (3) via linear programming methods such as DEA. Conventional production function approaches are semiparametric at best, and require additional procedures to eliminate biases that arise due to correlation between factor inputs and unobservable shocks to productivity (Levinsohn & Petrin 2003; Olley & Pakes 1996), or explicit functional form and/or distributional assumptions (Aigner, Lovell & Schmidt 1977; Meeusen & van den Broeck 1977). In contrast, DEA provides nonparametric estimates of TFP changes, which imposes considerably less structure than other comparable methodologies.

[5] Färe *et al.* (1994b) further show that the equivalence of (5) to the residual measure in Solow (1956) also assumes that all productivity changes result from outward shifts in technology, with no gains due to productive efficiency.

[6] In the appendix, we document these conditions more explicitly.

[7] Note that in this case, changes in the Malmquist index cannot be strictly interpreted as changes to TFP. Moreover, Ray & Desli (1997) have noted that consistency requires that this additional decomposition be performed only on a variable-returns specification for the original decomposition. Since we are keen to maintain our TFP interpretation of productivity, we only consider this secondary decomposition in the context of seeking to understand the channels where governance operates on productivity, while acknowledging the slight inconsistency with our constant-returns baseline.

3 Empirical Methodology

3.1 Data envelopment analysis

We apply nonparametric DEA techniques to estimate the directional distance function (3), which are used to calculate changes in TFP (5). DEA relies on linear programming to construct a piecewise linear representation of the (best-practice) production frontier, based on observed firm data (Charnes *et al.* 1978). Each firm—typically referred to as decision making units (DMU) in the literature—is represented by outputs and inputs, which in our application we limit to a single output (revenue) and two inputs (labor and capital). The solution to the linear program yields coefficients that are used to estimate firm-specific distance functions.

Our DEA model is input-oriented—that is, the linear program solves the problem via minimization of inputs rather than the output-maximization dual—and assumes constant returns to scale. The optimization generates firm-specific efficiency scores that range between 0 and 1, with unity being the most efficient. To preserve production technology heterogeneity between sectors and allow for shifts in the frontier over time, we compute global production frontiers, by sector, for each period (that is, for a given period t, we assume a static global sector-specific production frontier), and establish each firm's efficiency score relative to this frontier.[8]

The efficiency scores are then used to calculate year-to-year Malmquist index-based changes in TFP, using the geometric mean (5) to preserve base neutrality.

3.2 Dynamic panel estimation with system GMM

Our second-stage estimates make use of system GMM (Arellano & Bover 1995; Blundell & Bond 1998) to obtain dynamic panel estimates of the determinants of TFP change. We supplement (6) with a lagged dependent variable—which is especially important since TFP is typically a persistent series (Solarin 2015)—along with the full complement of fixed effects.[9] Our linear-log specification empirical specification is thus

$$\Delta TFP_{fgh,t+1} = \chi \Delta TFP_{fgh,t} + \mu + \mu_f + \mu_g + \mu_h + \mu_t + \beta_0 IQ_t + \mathbf{C}'_{h,t}\boldsymbol{\beta} + \mathbf{D}'_{f,t}\boldsymbol{\delta} + \epsilon_{fgh,t}, \tag{7}$$

where $\mathbf{C}$ and $\mathbf{D}$ are vectors of country and firm controls (other than institutional quality, IQ, which is our variable of interest), μ is a constant term, and μ_f, μ_g, μ_h, and μ_t are firm, sector, country, and period fixed effects.[10] $\epsilon \sim N\left(0, \sigma_\epsilon^2\right)$ is an i.i.d. innovation term. The scalar χ and vectors $\boldsymbol{\beta}$ and $\boldsymbol{\delta}$ are coefficients to be estimated. Our coefficient of interest is β_0, which captures the effect of institutional quality on changes in firm TFP.

In our baseline, we populate $\mathbf{C}$ with GDP per capita, private credit, capital account openness, and trade openness. $\mathbf{D}$ includes the log of assets, the ratios of market-to-book and equity-to-assets, leverage, and net income to assets (commonly known as the return on assets, or ROA). (7) is estimated by treating credit and openness as predetermined—and hence entered with one or more lags in the (orthogonalized) instrument matrix—while the remainder of the variables are treated as fully endogenous and entered with two lags (or deeper). We collapse the instrument set to limit instrument proliferation (Roodman 2009), and correct all standard errors to account for heteroskedasticity and arbitrary patterns of autocorrelation within countries.

[8] While we view this relativism as a strength of the nonparametric approach, it should be noted that some authors—for example Dyson *et al.* (2001) and Färe, Grosskopf & Lovell (1994a)—caution that DEA can be sensitive to measurement problems, especially when outliers are present. We recognize this potential issue, and in our robustness checks, we challenge the veracity of our baseline measures to outlier issues by treating two-year averages as a period.

[9] It is well-recognized that the inclusion of a lagged dependent variable in a fixed effects system may give rise to Nickell (1981) bias in coefficient estimates. However, one important advantage of system GMM is that it resolves this issue via an orthogonal deviations transform.

[10] Note that since the institutional measures do not vary much over time, we omit country fixed effects, in order to avoid issues associated with collinearity.

3.3 Identification considerations

As discussed above, our nonparametric DEA-based productivity measure offers what we believe to be more precise estimates of productivity than alternative parametric approaches, especially in contexts where production functions are likely to differ. However, one could reasonably argue—as Dyson *et al.* (2001) do—that the homogeneity assumptions implicit in DEA means that genuine environmental differences could mistakenly be attributed to inefficiencies instead. Given our approach, we believe that such concerns are likely to be limited.

For starters, we are careful to apply our DEA computations by sector, and for relatively brief time periods. This maintains the plausible assumption that firms within a given sector employ the same production technology within the period—and so variations are entirely due to productivity differences within this setting—while preserving the flexibility that the frontier can shift endogenously (or exogenously, due to shocks) over time. Furthermore, the entire focus of our work is to establish how country-level environmental factors—in particular variations in institutional quality—can have an influence on firm productivity. Consequently, our inclusion of institutional measures, along with other relevant country-level controls, is designed to investigate the possibility of a nonhomogeneous environment. Ultimately, the issue comes down to a tradeoff between a Type I versus Type II error; in our view, the risk of incorrectly identifying a productivity differential due to the homogeneity assumption in DEA (a Type I error) is more than outweighed by the benefits of and being able to capture possible cross-country variations in measured TFP (the failure of which would entail a Type II error).

There is a separate issue of identification, related to the possibility of endogeneity of the institutional quality measure. Since our estimates of productivity are measured at the firm level, simultaneity bias is unlikely to be an issue (any individual firm is unlikely to be able to single-handedly alter their country's institutional environment). In any case, we follow (5) and take lags of all variables on the right hand side, which will further attenuate simultaneity.

That said, there could still be omitted confounding variables. We address this concern by including fixed effects for as many dimensions as possible in our second-stage specifications: at the firm, year, and sector level. In addition, we utilize internal instrument (in the baseline) and a commonly-used set of external instruments (in robustness checks) to ensure identification of the key institutional variable.

3.4 Data sources and description

Our data are derived from two primary sources. The firm-level data are from Thomson-Reuters' *Worldscope* database, and are classified according to their 2-digit SIC manufacturing sector. These firms are then matched with country-level data corresponding to their country of domicile. For institutional quality—our variable of interest—we utilize the World Bank's *World Governance Indicators* (WGI), and supplement this with institutional measure from the World Economic Forum's *Global Competitiveness Report* (GCR) and the World Bank's *Doing Business*(DB) database (both of which we use for robustness checks). Additional macroeconomic controls were drawn from the World Bank's *World Development Indicators.*

For firm inputs, labor is measured as the number of employees (both full time and part-time) employed in the company, while capital is defined as fixed tangible assets (net property, plant and equipment). Firm output is proxied by total sales or revenue. The other firm-level controls, such as the firm's total assets or the market-to-book ratio, are fairly standard in the firm literature, and described in detail in the appendix.

Our main measure of institutional quality is the first principal component of the six different governance measures in the WGI,[11] although we also consider each of these indicators individually. For

[11] These are: control of corruption, government effectiveness, political stability, regulatory quality, rule of law, and voice and accountability. See Kaufmann, Kraay & Mastruzzi (2011) for details on the methodology used to construct these measures.

robustness, our alternative measures are the first principal component of eight institutional indicators in the GCR,[12] the first principal component of four DB quantitative indicators,[13] as well as each of these individual indicators separately.

The other country-level controls, such as GDP per capita and trade openness, are also standard measures in the cross-country regression literature, and are likewise described in the appendix.

Our baseline is an unbalanced panel, where production frontiers are calculated annually for manufacturing sectors that fall between the Standard Industrial Classification (SIC) groups SIC 20–SIC 39. To avoid distortions due to small samples, we drop industries that includes less than 5 firms, and to limit outliers, we winsorize the data by removing firms in the top and bottom one percentile for each of the explanatory variables used in our model. This results in a working sample of 21,695 observations, comprising 3,446 firms based in 58 DM and EM economies, distributed over 2006–14 (with the average firm contributing 6 years' worth of observations), and across 14 sectors. Standard summary statistics for the main variables are reported in the appendix.

4 Results

4.1 Bivariate relationships

We provide an overture of how changes in firm TFP is related to institutional quality in Figure 1, which is a scatterplot of the two variables, using averages across firms and time to obtain a representative value for each country, along with a simple linear fit. The figure provides a striking summary of how important a country's institutional quality is for TFP growth: for the period 2006–14, the average change in firm TFP is significantly greater for countries with high governance indexes. For instance, were Indonesia (which scores approximately -4 on the governance index) to improve its governance to were to improve to that of Malaysia (about -1 on the index), the average firm would experience a more-than-threefold improvement in its productivity growth.

Of course, such averages suppress both within-country variation in firm TFP, as well as trend changes that may alter our conclusion about the importance of institutional quality. For this reason, and to further condition the effect on additional observable covariates and unobservable fixed effects, we turn to the formal panel regressions.

4.2 Baseline regressions

Table 1 reports our baseline results. The final column, which is our preferred specification, is the regression with the full set of fixed effects along the lines of (7). The preceding columns include various permutations, with and without the full complement of sectoral effects and firm- and country-specific controls; for example, column 2 reports a bare-bones specification with only firm, sector, country, and period fixed effects, but no additional time-varying controls.

Some preliminaries: for all reported specifications in Table 1, the included variables are jointly significant (as measured by the Wald χ^2 test), and insignificant Hansen Js from tests of overidentifying restrictions support the coherence (Parente & Santos Silva 2012) of the instrument set. The insignificant z statistics for the Arellano-Bond AR(2) tests also indicate that the chosen lag structure for the instruments are not an issue. The instrument count may appear somewhat high—especially for the preferred specification—but given the large number of observations, instrument proliferation (Roodman 2009) is relatively contained.

[12]These are: investor protection, property rights, regulatory burden, shareholder protection, auditing/reporting strength, customs burden, FDI rules, and hiring/firing practices.
[13]These are: enforcing contracts, registering property, resolving insolvency, and protecting investors.

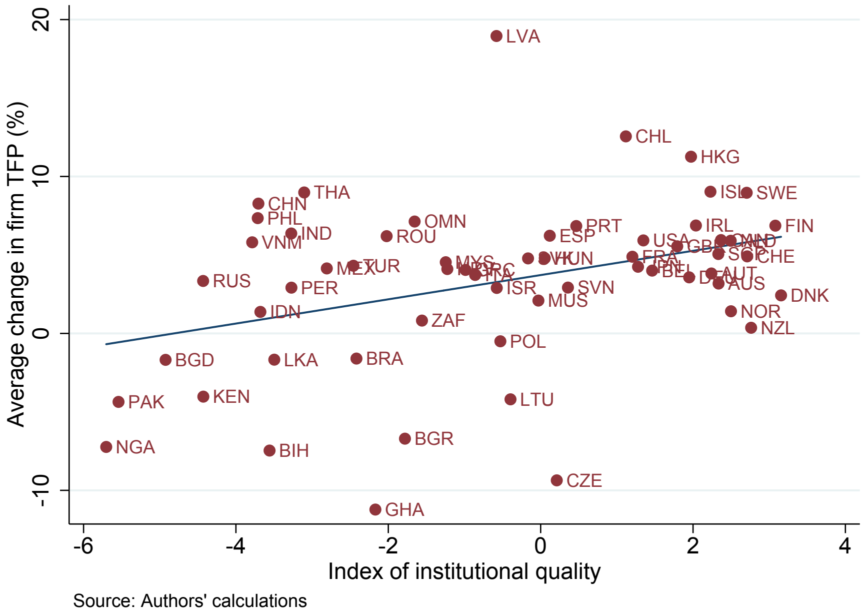

Figure 1: Bivariate relationship between the average percentage change in TFP across all firms and periods for a given country, against the index of institutional quality. The navy line is the best linear fit obtained using OLS. The positive relationship between average TFP growth and the quality of a country's institutions is evident.

It is clear from the results that institutional quality exerts both a statistically and economically significant conditioning effect on changes in firm TFP. Estimates of the coefficient β_0 fall within the range $[0.17, 0.96]$, with the effect in our preferred specification estimated at 0.17. Thus, for a one-unit improvement in the quality of institutions in any given country, the average firm will experience a change in its TFP of 0.17 percent on the Malmquist index. To put this in perspective, this change is equivalent to an improvement of about 0.4 standard deviations relative to the mean, and has an effect around 4 times larger than a firm's valuation (as proxied by the market-to-book ratio), and of a similar order of magnitude to changes in a country's level of development. It is also several orders of magnitude larger than effects from factors conventionally associated with improvements in productivity, such as trade openness (Clerides, Lach & Tybout 1998; Pavcnik 2002) and financial development (Benhabib & Spiegel 2000; Galindo, Schiantarelli & Weiss 2007) (both of which are not statistically distinguishable from zero in our results).[14] Finally, it is worth pointing out that while system GMM exploits both between and within variation in computing (efficient) estimates, the relatively modest temporal variation in institutional quality implies that most of the effects of institutions on TFP likely derives from cross-country differences.

To gain further intuition behind these results, consider the effect of improvements to governance in a country—such as Indonesia—which falls in the lowest quartile of countries in terms of institutional quality, such that it attains a level equivalent to Austria, a country in the highest quartile. Keeping the effect of all other variables constant at their mean values, such an improvement in institutional quality would imply TFP rising by 159 percent (from 0.54 to 1.40), a substantial increase. Even a more modest improvement to the institutional quality of an economy such as Israel (which is at the median of the institutional quality distribution) would still see TFP rising by 83 percent.

[14] An important caveat is that result on trade openness here is at the country level and does not invalidate the literature that finds that productivity among exporting firms tends to dominate those of non-exporters; that is, the two results are not mutually exclusive. A more comprehensive analysis of how institutions interact with a firm's position on international trade is intriguing, but would go beyond the scope of the present paper; we leave this question to future research.

Table 1: Baseline regressions for change in firm productivity and institutional quality, 2006–14†

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Lagged TFP change	0.616	0.540	0.029	-0.006	0.033	-0.006
	(0.705)	(0.423)	(0.042)	(0.034)	(0.053)	(0.030)
Institutional quality	0.858	0.961	0.208	0.258	0.205	0.168
	(0.291)***	(0.467)**	(0.121)*	(0.155)*	(0.113)*	(0.069)**
			Firm covariates			
Assets			-0.093	0.024	-0.078	-0.043
			(0.078)	(0.109)	(0.106)	(0.052)
Market-to-book			-0.037	0.012	-0.041	-0.043
			(0.035)	(0.059)	(0.047)	(0.024)*
Equity-to-assets			-0.515	-0.059	-1.371	-1.338
			(0.869)	(1.592)	(1.166)	(0.970)
Leverage			-0.027	0.185	-0.979	-1.012
			(0.737)	(1.375)	(1.093)	(0.921)
ROA			-0.357	-0.813	-0.766	-0.604
			(0.348)	(0.759)	(0.919)	(0.509)
			Country covariates			
GDP per capita					-0.040	-0.195
					(0.141)	(0.060)***
Financial development					-0.000	-0.000
					(0.001)	(0.000)
Trade openness					0.001	-0.000
					(0.001)	(0.001)
Financial openness					0.067	-0.054
					(0.212)	(0.092)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Sector fixed effects	No	Yes	No	Yes	No	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Wald χ^2	33,371.3***	30,140.0***	22,443.5***	1,387.3***	75,127.0***	2,698.6***
Overid. J	0.144	1.287	20.034	11.026	9.394	18.296
AR(2) z	0.813	1.212	-0.213	-1.184	-0.210	-1.195
Estimation	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM
Instruments	70	85	99	38	50	109
Obs.	21,695	21,695	21,695	21,695	21,695	21,695
Firms (countries)	3,446 (58)	3,446 (58)	3,446 (58)	3,446 (58)	3,446 (58)	3,446 (58)

† The dependent variable is the annual change in Malmquist firm-level TFP. The institutional quality measure is the lagged first principal component of the six WGIs. All firm and country covariates are lagged by one period. A constant term is included in all specifications, but not reported. Regressions are estimated using two-step system GMM, with collapsed instrument sets and the forward orthogonal deviations transform. Heteroskedasticity and host country correlation-robust Windmeijer-corrected standard errors are reported in parentheses. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level. The overidentification test is the Hansen J, and the AR(2) test is the Arellano-Bond first differences z.

Finally, most of the other time-varying country- and firm-level controls are not statistically significant. This is not entirely surprising, given our inclusion of fixed effects. That said, in cases where they are, the sign of the coefficients accord with intuition. For instance, the coefficient on GDP per capita is negative, which is consistent with diminishing returns and the convergence hypothesis, where productivity growth is expected to slow in higher-income economies as they approach the steady state. Similarly, TFP growth is higher with firms that acquire more leverage, possibly because the increased financial access afforded by borrowing allows the firm to invest in productivity-enhancing measures.

5 Robustness

5.1 Alternative institutional measures

Although we regard our use of a principal component index as the best means of capturing the essential core of cross-country variations in institutional quality, the quality of the index is ultimately constrained by our choice of inputs (which, in our baseline, are the World Bank's WGI measures). In this section we use other available governance measures in the literature to construct principal component indexes, while also repeating the exercise of decomposing these measures into various components in order to better understand the nature of the institutions that matter.

We consider two alternative measures of institutions: (a) the World Bank's Doing Business measures; and (b) the World Economic Forum's Global Competitiveness Report measures.[15] For both of these indicators, we choose a subset of the available measures for DB and the GCR, guided by two principles: whether the measures related to country-level institutions that could potentially affect firm activity, and whether they were cardinal (rather than ordinal) in nature (to permit comparison across time). These are reported in Tables 2 and 3, respectively. For each table, the first column presents results with the first principal component constructed from the constituent subindicators, while the remaining ones correspond to the various subindicators as documented in the top row.

The overarching message in these two tables is that our finding that institutional quality is important for changes in firm TFP continue to hold, even with these alternative measures. Looking at the results in first column of both tables, the coefficient on the composite business environment measure (corresponding to the Doing Business data) is 0.15, very similar to our preferred baseline estimate of 0.17. In contrast, the coefficient on the business competitiveness measure (corresponding to the Global Competitiveness Report), while statistically significant, is an order of magnitude smaller. We attribute this to the fact that the first principal component of a larger number of subcomponent measures is likely to embed comparatively more noise. Indeed, for certain subindicators—such as investor protection in the second column—the magnitude of the institutional effect exceeds that of the baseline.

We postpone further discussion of the results reported in the subsequent columns of Tables 2 and 3 to section 6.3, where we take up the issue of unbundling the institutional measure.

[15] In the appendix, we consider another alternative measure, the Heritage Foundation's Economic Freedom Index. While our qualitative results continue to hold with this measure, we relegate this set of results to the appendix because we regard the concept of economic freedom—with the exception of the property rights index—as distinct from the sort implied by our other measures. In particular, many economic freedoms may suggest a bias toward *less* government action, as opposed to *better* overall governance, which may or may not entail a rollback of governance institutions and strictures. Nevertheless, the results are qualitatively similar, and the coefficient on the composite economic freedom measure is very close to that of our preferred baseline.

Table 2: Regressions for change in firm productivity and alternative institutional quality measure (Doing Business), 2006–14†

	Business env **(1)**	*Enf contracts* **(2)**	*Reg property* **(3)**	*Res insolv* **(4)**	*Prot inv* **(5)**
Lagged TFP	-0.020	-0.015	-0.019	-0.018	-0.007
change	(0.035)	(0.032)	(0.037)	(0.036)	(0.042)
Institutional	0.149	0.016	0.003	0.008	0.002
quality (DB)	(0.087)*	(0.007)**	(0.002)**	(0.002)***	(0.013)
Firm covariates	Yes	Yes	Yes	Yes	Yes
Country covariates	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes
Wald χ^2	58,871.5***	21,240.0***	58,640.0***	27,550.0***	18,125.9***
Overid. J	3.096	8.79	3.065	2.955	6.156
AR(2) z	-1.376	-1.588	-1.366	-1.496	-1.606
Estimation	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM
Instruments	96	101	96	96	97
Obs.	19,669	19,669	19,669	19,669	19,669
Firms (countries)	3,444 (58)	3,444 (58)	3,444 (58)	3,444 (58)	3,444 (58)

† The dependent variable is the annual change in Malmquist firm-level TFP. The institutional quality measures are the lagged first principal component of four selected state governance-related cardinal DB measures (column 1), and the lagged value for each of four DBs (enforcing contracts, registering property, resolving insolvency, protecting minority investors) listed on the first row (columns 2–5). All firm and country covariates are lagged by one period. A constant term is included in all specifications, but not reported. Regressions are estimated using two-step system GMM, with collapsed instrument sets and the forward orthogonal deviations transform. Heteroskedasticity and host country correlation-robust Windmeijer-corrected standard errors are reported in parentheses. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level. The overidentification test is the Hansen J, and the AR(2) test is the Arellano-Bond first differences z.

Table 3: Regressions for change in firm productivity and alternative institutional quality measure (Global Competitiveness Report), 2006–14†

	Business comp (**1**)	*Inv prot* (**2**)	*Prop rights* (**3**)	*Gov reg* (**4**)	*Shrhldr prot* (**5**)	*Audit qual* (**6**)	*Cust burden* (**7**)	*FDI rules* (**8**)	*Hiring/firing* (**9**)
Lagged TFP	-0.035	-0.004	-0.051	0.264	-0.005	0.003	-0.007	0.044	0.084
change	(0.033)	(0.044)	(0.058)	(0.289)	(0.044)	(0.258)	(0.043)	(0.279)	(0.251)
Institutional	0.014	0.289	0.071	0.057	0.037	0.038	0.022	0.084	0.000
quality (GCR)	(0.007)**	(0.119)**	(0.032)**	(0.033)*	(0.015)**	(0.017)**	(0.033)	(0.019)***	(0.027)
Firm covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wald χ^2	3×10^{8}***	1,916,708***	122,453***	1,322,844***	6,426,676***	1,319,405***	43,479.8***	5,843.8***	10,015.8***
Overid. J	2.216	6.809	19.194	6.447	8.589	10.797	8.427	12.487	10.692
AR(2) z	-1.498	-0.523	-1.417	0.812	-1.063	-0.245	-1.211	0.029	0.193
Estimation	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM
Instruments	93	102	107	99	99	101	99	101	101
Obs.	16,979	16,979	16,979	16,979	16,979	16,979	16,979	16,979	16,979
Firms (countries)	3,419 (57)	3,419 (57)	3,419 (57)	3,419 (57)	3,419 (57)	3,419 (57)	3,419 (57)	3,419 (57)	3,419 (57)

† The dependent variable is the annual change in Malmquist firm-level TFP. The institutional quality measure is the lagged first principal component of eight selected state governance-related GCR measures (column 1), and the lagged value for each of the eight GCRs (investor protection, property rights, government regulation, shareholder protection, auditing/reporting quality, customs burden, business impact of FDI rules, hiring/firing practices) listed on the first row (columns 2–9). All firm and country covariates are lagged by one period. A constant term is included in all specifications, but not reported. Regressions are estimated using two-step system GMM, with collapsed instrument sets and the forward orthogonal deviations transform. Heteroskedasticity and host country correlation-robust Windmeijer-corrected standard errors are reported in parentheses. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level. The overidentification test is the Hansen J, and the AR(2) test is the Arellano-Bond first differences z.

5.2 Variations in model specification

We next consider variations to the model specification used for our baseline. For instance, one may dispute the inclusion of a number of firm-specific fixed factors, on the basis that these may either not be fully exogenous, or that they may suffer from excess correlation with the other included factors. Two of these, in particular, may be of concern: the inclusion of net income (which, for stable costs, may be correlated to the revenue stream and hence assets) as well as leverage (which Margaritis & Psillaki (2010), among others, have argued may be endogenous). More generally, one may wish to limit the number of additional fixed factors used as controls in order to avoid collinearity issues, given the fact that firm fixed effects are already embedded. Accordingly, we rerun our baseline allowing for the exclusion of either net income only (column 2 of Table 4), leverage only (column 3), or both (column 4).

Table 4: Regressions for change in firm productivity and institutional quality, excluding (potentially endogenous) firm covariates, 2006–14[†]

	(1)	**(2)**	**(3)**	**(4)**
Lagged TFP	-0.006	-0.009	-0.009	-0.001
change	(0.030)	(0.035)	(0.031)	(0.020)
Institutional	0.168	0.343	0.378	0.383
quality	(0.069)**	(0.149)**	(0.127)***	(0.100)***
Excluding:				
Leverage	No	No	Yes	Yes
Net income	No	Yes	No	Yes
Including:				
Other firm covariates	Yes	Yes	Yes	Yes
Country covariates	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes
Wald χ^2	2,698.6***	64,753.3***	6,512.7***	
Overid. J	18.296	13.934	15.523	21.113
AR(2) z	-1.195	-1.592	-1.097	-0.925
Estimation	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM
Instruments	109	103	107	107
Obs.	21,695	21,695	21,695	21,695
Firms (countries)	3,446 (58)	3,446 (58)	3,446 (58)	3,446 (58)

[†] The dependent variable is the annual change in Malmquist firm-level TFP. The institutional quality measure is the lagged first principal component of the six WGIs. All firm and country covariates are lagged by one period. A constant term is included in all specifications, but not reported. Regressions are estimated using two-step system GMM, with collapsed instrument sets and the forward orthogonal deviations transform. Heteroskedasticity and host country correlation-robust Windmeijer-corrected standard errors are reported in parentheses. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level. The overidentification test is the Hansen J, and the AR(2) test is the Arellano-Bond first differences z.

By and large, the exclusion of these variables do not have any qualitative effect on our results. In fact, excluding these controls substantially improves the overall fit of the model (as evidenced by the Wald χ^2 statistics), without really compromising the instrument set (p-values for the overidentification tests remain insignificant). At the same time, the coefficient on the institutional quality measure actually *increases*, in both magnitude—roughly doubling, on average—while becoming more precisely measured (two of the three p-values become significant at the 1 percent level). We are led to conclude that changing the model to adjust for the choice of time-varying firm fixed factors do not substantially alter our results.

5.3 Inclusion of external instruments

As discussed in Section 3.3, our baseline relies essentially on internal instruments to obtain our results, since it is unlikely that reverse causality would emerge from firm-institution interactions. Nevertheless, in this section we explore the effect of including external instruments into our instrument set. We rely on two sets of measures that are fairly established in the literature: English and French legal origin (La Porta, López-de Silanes, Shleifer & Vishny 1998), the fraction of the population speaking English and other European languages (Hall & Jones 1999), and the extent of ethnic, linguistic, and religious fractionalization (Alesina, Easterly, Devleeschauwer, Kurlat & Wacziarg 2003). Regressions that include various permutations of these instruments are reported in first through fifth columns of Table 5.

Table 5: Regressions for change in firm productivity and institutional quality, using external instruments, and for 2-year averages, 2006–14†

	European languages **(1)**	*European leg origin* **(2)**	*Language & leg origin* **(3)**	*Ethno-ling-rel frac* **(4)**	*ELRF, lang & leg* **(5)**	*2-year averages* **(6)**
Lagged TFP change	-0.003	-0.023	-0.004	-0.031	0.022	-0.015
	(0.030)	(0.038)	(0.031)	(0.037)	(0.038)	(0.061)
Institutional quality	0.150	0.348	0.149	0.464	0.261	0.174
	(0.047)***	(0.158)**	(0.058)**	(0.186)**	(0.067)***	(0.044)***
Firm covariates	Yes	Yes	Yes	Yes	Yes	Yes
Country covariates	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Wald χ^2	8,536.2***	1,680.4***	2,710.7	3,637.0***	1,380.5	1,430,065.2***
Overid. J	17.663	8.866	18.079	4.267	10.141	11.454
AR(2) z	-1.111	-1.274	-1.146	-1.321	-0.58	0.844
Estimation	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM	
Instruments	109	105	109	99	104	96
Obs.	21,695	21,695	21,695	21,695	21,695	10,190
Firms (countries)	3,446 (58)	3,446 (58)	3,446 (58)	3,446 (58)	3,444 (58)	

† The dependent variable is the annual change in Malmquist firm-level TFP. The institutional quality measure is the lagged first principal component of the six WGIs, estimated with additional external instruments (European language share, European legal origin, ethno-linguistic-religious fractionalization) listed on the first row (columns 1–5). Column 6 replicates the baseline using two-year averages instead. All firm and country covariates are lagged by one period. A constant term is included in all specifications, but not reported. Regressions are estimated using two-step system GMM, with collapsed instrument sets and the forward orthogonal deviations transform. Heteroskedasticity and host country correlation-robust Windmeijer-corrected standard errors are reported in parentheses. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level. The overidentification test is the Hansen J, and the AR(2) test is the Arellano-Bond first differences z.

The results remain remarkably stable regardless of the specific set of external instruments we employ. In the majority of cases, the coefficients remain within one standard error of our preferred baseline, and in the cases where they differ more (columns 2 and 4), the magnitude of the coefficient is actually higher, while remaining statistically significant. We are led to conclude that endogeneity concerns in our variable of interest do not alter our conclusions.

5.4 Changes to time period aggregation

We also consider the possibility that our reliance on annual changes in the may bias our results, either because of the possibility that the technological frontier may remain fixed for a longer period, because of the risk of instrument proliferation,[16] or simply to smooth out the effects of temporary cyclical movements. Nevertheless, we consider an alternative aggregation scheme that takes two-year averages of all variables, and repeats our baseline exercise. This is reported in the final column of Table 5. As before, our qualitative results are unchanged by this alternative aggregation choice, and the effect of institutional quality is essentially statistically identical to our baseline estimate.

5.5 Subsamples of the data

Finally, we examine the robustness of our results to a number of alternative subsample slices of the data. The first split we perform is to subdivide our working sample into advanced and developing economies (columns 1–2 of Table 6). Our prior is that the institutional environment is likely to be more important for TFP performance in developing countries. Second, we separate the sample by changes in TFP (our dependent variable) according to the bottom and top halves of the distribution (columns 3–4), under the notion that it will be instructive to understand how important institutional quality is for the productivity out/under-performers. Third, we explore the extent to which firm size matters (columns 5–6), since firm size may be reflective of systematic differences in firm performance that are not well captured by observable covariates.

Table 6: Regressions for change in firm productivity for different subsample splits, 2006–14†

	Advanced (**1**)	*Developing* (**2**)	ΔTFP $< 50p$ (**3**)	ΔTFP $> 50p$ (**4**)	*Assets* $< 50p$ (**5**)	*Assets* $> 50p$ (**6**)
Lagged TFP	-0.130	0.065	-0.005	-0.103	-0.062	0.037
change	(0.064)**	(0.025)***	(0.065)	(0.309)	(0.082)	(0.021)*
Institutional	0.181	0.081	0.381	0.617	0.166	0.597
quality	(0.109)*	(0.031)***	(0.354)	(0.181)***	(0.154)	(0.118)***
Firm covariates	Yes	Yes	Yes	Yes	Yes	Yes
Country covariates	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Wald χ^2	496.2***	6,535.4***	1,467.6***	11,983.5***	4,736.9***	120.4***
Overid. J	6.831	3.668	22.110	14.110	10.937	10.423
AR(2) z	-1.071	-0.266	-1.476	-1.195	-0.707	-0.513
Estimation	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM
Instruments	75	73	107	103	106	99
Obs.	19,669	19,669	19,669	19,669	19,669	19,669
Firms (countries)	2,384 (28)	1,062 (30)	3,363 (58)	3,337 (57)	1,760 (54)	2,129 (52)

† The dependent variable is the annual change in Malmquist firm-level TFP, for the subsample listed on the first row. The institutional quality measure is the lagged first principal component of the six WGIs. All firm and country covariates are lagged by one period. A constant term is included in all specifications, but not reported. Regressions are estimated using two-step system GMM, with collapsed instrument sets and the forward orthogonal deviations transform. Heteroskedasticity and host country correlation-robust Windmeijer-corrected standard errors are reported in parentheses. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level. The overidentification test is the Hansen J, and the AR(2) test is the Arellano-Bond first differences z.

[16] However, this latter concern is unlikely to be a problem, since the average length of the unbalanced panel, as noted earlier, is 6 years; the bias in this case is of order $O\left(\frac{jT}{N}\right)$ (Arellano 2016), so given the relatively large cross-sectional size and relatively short time period, the risk of overfitting due to instrument proliferation is likely to be limited.

The effect of institutional quality is positive and significant for the developing country subsample, while only marginally significant for the advanced economy one. This is consistent with our prior that governance effects are more important in developing countries. That said, the coefficient on the advanced economy subsample is of a greater magnitude, which is not entirely surprising given how any measured effect would tend to be larger for high-income countries where productivity is also, on average, greater.

The result for the TFP split indicates that it is the firms for which productivity growth has been greatest that is central to our results: the coefficient on institutional quality in column 4 is not only statistically significant (compared to the insignificant coefficient in column 3), but around three times larger in magnitude. This complements some of the recent literature, such as McGowan *et al.* (2015), that has demonstrated that the most productive firms have continued to outperform even after the global crisis of 2007/08. The result here lends additional support to this claim, but further reveals that the contribution from firms at the productivity frontier is heavily conditioned by the country's quality of institutions.[17]

Finally, the division of the sample by assets corroborates a result that is well-established in the firm-level TFP literature: that larger firms tend to be more productive, whether in industrialized (van Ark 1995) or developing (van Biesebroeck 2005) economies. Our results further refine this stylized fact by noting that the half of the distribution of firms, by size, are a key driver of our finding that TFP growth is mediated by institutional quality.[18]

6 What Institutions Matter and Why Do They Matter?

6.1 Unbundling institutions

Is there a specific institutional mechanism that is driving this result? To gain insight into this, we take the cue from authors such as Acemoğlu & Johnson (2005), Bartelsman, Haltiwanger & Scarpetta (2010), and Williamson & Kerekes (2011) and consider whether distinct types of institutions and business climates affect TFP growth differentially. We repeat the regressions of our preferred baseline specification, but substitute the combined institutional measure with each of the six subindicators of governance in the WGI.[19] These are reported in columnns 2–7 of Table 7 (the baseline with the aggregate measure replicated in the first column for reference). *Ceteris paribus*, one would expect that indicators that are likely to affect the operating environment of the firm—such as the rule of law and regulatory quality—to cast a greater shadow on TFP growth that diffused measures, such as voice and accountability.

While this hypothesis is indeed verified by the results in columns 4 and 6, the magnitude of the coefficient on voice is remarkably high: 0.39, more than the overall governance effect and significantly greater than factors, such as corruption, which one may reasonably expect to be important to TFP growth (the magnitude of the coefficient on voice is only exceeded by that on regulation and rule of law). We interpret this to mean that democratic values are an important enabler for improved firm productivity, possibly because in countries where this is the case, entrepreneurs are more easily able to exchange local knowledge and access international best practices (recall, given the fixed country effects and system GMM estimation, it is unlikely that this result is simply because voice is coincidentally correlated with TFP changes or attributable to pure selection effects).

[17]This finding also holds when we split the sample into thirds by TFP growth, and consider the top and bottom thirds of the distribution. The coefficient on institutional quality in the upper tertile is 0.912 (s.e. = 0.495, p = 0.09), even larger than for the upper half of the distribution (full details are available on request). A summary of these subsample coefficients is provided in Figure **??** in the appendix.

[18]Indeed, it is possible to argue for the consistency of our findings with those reported in Bartelsman, Haltiwanger & Scarpetta (2013), where the size-productivity linkage to productivity occurs via cross-country variation in policy distortions.

[19]Since the combined measure is the first principal component of the subindicators, the measure is orthogonal to cross-correlations among subindicators, by definition. However, including the full set of each of subindicators risks multicollinearity, which is why we eschew the inclusion of them together.

Table 7: Regressions for firm productivity and institutional quality subindicators, 2006–14†

	Inst index (1)	*Voice & acc* (2)	*Pol stab* (3)	*Reg qual* (4)	*Govt eff* (5)	*Rule law* (6)	*Corrupt* (7)
Lagged TFP	-0.006	-0.003	0.016	0.042	0.056	0.025	-0.014
change	(0.030)	(0.035)	(0.037)	(0.040)	(0.043)	(0.040)	(0.047)
Institutions	0.168	0.393	0.174	0.631	0.227	0.474	0.072
subindicator	(0.069)**	(0.093)***	(0.072)**	(0.291)**	(0.119)*	(0.114)***	(0.036)**
Firm covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wald χ^2	2,698.6***	3,555.5***	6,855.4***	8,692.1***	105,857.9***	3,121.8***	7,291.1***
Overid. J	18.296	23.226	9.119	9.499	10.054	13.46	16.395
AR(2) z	-1.195	-1.070	-0.562	-0.300	0.140	-0.467	-1.268
Estimation	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM
Instruments	109	107	108	102	102	108	109
Obs.	21,695	21,695	21,695	21,695	21,695	21,695	21,695
Firms (countries)	3,446 (58)	3,446 (58)	3,446 (58)	3,446 (58)	3,446 (58)	3,446 (58)	3,446 (58)

† The dependent variable is the annual change in Malmquist firm-level TFP. The institutional quality measures are the lagged principal component index (column 1), and the lagged value for each of the six component WGIs (voice & accountability, political stability, regulatory quality, government effectiveness, rule of law, and control of corruption) listed on the first row (columns 2–7). All firm and country covariates are lagged by one period. A constant term is included in all specifications, but not reported. Regressions are estimated using two-step system GMM, with collapsed instrument sets and the forward orthogonal deviations transform. Heteroskedasticity and host country correlation-robust Windmeijer-corrected standard errors are reported in parentheses. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level. The overidentification test is the Hansen J, and the AR(2) test is the Arellano-Bond first differences z.

In contrast, an institutional factor often perceived as an impediment to business practices—corruption—is significant, but of far less importance than even a measure such as government effectiveness, which appears *ex ante* to only be of second-order importance, governing only indirect interactions that firm have with the state when they access public services or are affected by overall macroeconomic policy management. Our conjecture is that many firms—especially those based in societies where informal payments are a part-and-parcel of doing business—are easily able to incorporate such additional costs into their firm decisionmaking processes, so that the effects of corruption on their productivity remains limited.

This general message—regarding the relative importance of rule of law and regulatory quality—is also corroborated by subindicators from our alternative measures of institutional quality. For example, the largest coefficients among the Doing Business subindicators are those on enforcing contracts (Table 2, column 2) and resolving insolvency (column 4), which are related to rule of law and regulatory quality, respectively; similarly, the coefficients on property rights (Table 3, column 3) and government regulation (column 4) from the Global Competitiveness Report enter with comparatively large magnitudes.[20,21]

[20] Note that the magnitudes of the coefficients on the subindicators are not, however, are not directly comparable *across* the different tables, since they are constructed using different cardinal scales.

[21] The notable exception from Table 3 is the sizable coefficient on investor protection, which is actually *in*significant in Table 2. Although there is no clearly analogous concept among the World Governance Indicators, investor protection is sometimes (imperfectly) bundled together with rule of law, in which case this finding is again consistent with our overall theme.

6.2 The role of corporate governance

The second angle that we approach the question of institutional form is to examine whether institutions that directly affect a firm's day-to-day operation and conduct. That is, we consider how *corporate*—as opposed to *state*—governance matters for productivity. There is now substantive evidence that corporate governance mechanisms alter firm behavior and performance in significant ways (Shleifer & Vishny 1997), including via productivity (Barth, Gulbrandsen & Schønea 2005; Chiang & Lin 2007; Köke & Renneboog 2005). We pursue this matter by exploiting a number of metrics in the Global Competitiveness Report that relate directly to corporate governance. These range from measures related to efficient usage of talent by firms (such as the strength of the relationship between "pay and productivity"), to corporate accountability processes (such as the strength of "auditing and reporting" standards), to general business conduct (the "ethical behavior" of firms). Since we are interested in how corporate governance relates to the institutional quality of the state, we introduce these measures as interaction terms. The results are reported in Table 8.

The first point we make is that, across the majority of the specifications, the effect of institutional quality remains positive and significant, even when we control for corporate governance. Hence, it is the overall institutional environment of the state that is key to firm productivity, not the specific ways that firms privately organize themselves.

A second point to note is that the composite corporate governance index is significant, albeit of an order of magnitude smaller in its effect on TFP, relative to state-level governance (column 1).[22] The uninteracted effect is negative: higher levels of corporate governance are associated with *lower* TFP growth. Although somewhat surprising, our interpretation of this outcome is that the residual effect of greater attention to corporate governance mechanisms—after accounting for state-level institutional quality—is likely to detract from efforts to improve the efficiency of firm operations, possibly due to limited managerial capacity. Moreover, the coefficient is only statistically significant (at conventional levels) in the first of the six specifications.

Our third and central takeaway concerns the interacted effects of institutional quality with our measures of corporate governance. Here, all but one of the specifications points to a significant negative conditioning effect: for a given level of institutional quality, further improvements in corporate governance may marginally reduce firm TFP growth (although by less than the effect of changes to state governance). Put another way, corporate governance matters less when overall state-level institutional governance is superior. That said, the *total* effect of institutions remains significantly positive for the full range of realizations for corporate governance, as shown in Figure 2.

6.3 Decomposing productivity

We now move on from identifying *what* types of institutional measures matter to asking *how* institutions matter. We address this question by exploiting the decompositions described in Section 2. The decomposition of TFP is reported in columns 2 and 3 of Table 9, while the next two columns report results with the additional decomposition into scale and pure efficiency components. As before, we include our baseline results for reference.

What is clear from comparing the second and third columns is that the effect of institutional quality on changes in firm TFP operates through improving productive efficiency, rather than inspiring technological advancement. The coefficient on efficiency change is actually positive, and larger in magnitude than the undecomposed measure; with the coefficient on technological change entering with a negative (albeit statistically insignificant) sign, this suggests that efficiency improvements are overwhelmingly the channel by which institutional quality alters firm TFP. It is also consistent with the sort of anecdotal evidence—some of which were described in the introduction—where poor quality governance appears to affect more

[22] The relatively small contribution of corporate, compared to state, governance holds even when we consider subindicators for corporate governance in the columns that follow.

Table 8: Regressions for change in firm productivity and institutional quality interacted with corporate governance, 2006–14[†]

	Corp index (**1**)	*Boards* (**2**)	*Auditing* (**3**)	*Ethics* (**4**)	*Mgmt* (**5**)	*Pay* (**6**)
Lagged TFP	0.325	0.012	0.064	0.149	0.005	0.009
	(0.179)*	(0.052)	(0.043)	(0.213)	(0.034)	(0.035)
Institutional quality	0.440	0.423	0.469	0.403	0.412	0.322
	(0.146)***	(0.165)**	(0.193)**	(0.151)***	(0.217)*	(0.207)
Corporate governance	-0.068	-0.118	-0.093	-0.039	-0.096	-0.032
	(0.025)***	(0.066)*	(0.067)	(0.039)	(0.070)	(0.055)
Institutions × corp gov	-0.013					
	(0.004)***					
Institutions × boards		-0.018				
		(0.012)				
Institutions × auditing			-0.039			
			(0.015)***			
Institutions × ethics				-0.033		
				(0.011)***		
Institutions × management					-0.028	
					(0.013)**	
Institutions × pay						-0.027
						(0.013)**
Firm covariates	Yes	Yes	Yes	Yes	Yes	Yes
Country covariates	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Wald χ^2	12,893.4***	9,807.0***	11,823.2***	2,458.5***	1,884.4***	1,948.3***
Overid. J	12.144	4.228	2.947	6.576	4.001	4.864
AR(2) z	1.411	-1.158	0.770	0.517	-1.104	-1.066
Estimation	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM
Instruments	107	101	100	105	99	99
Obs.	19,669	19,669	19,669	19,669	19,669	19,669
Firms (countries)	3,444 (58)	3,444 (58)	3,444 (58)	3,444 (58)	3,444 (58)	3,444 (58)

[†] The dependent variable is the annual change in Malmquist firm-level TFP. The institutional quality measure is the lagged first principal component of the six WGIs. The corporate governance measures are the lagged first principal component of the five corporate governance-related GCR measures (column 1), and the lagged value for each of the five GCRs (efficacy of corporate boards, strength of auditing and reporting standards, ethical behavior of firms, reliance on professional management, and pay & productivity) listed on the first row (columns 2–6). All firm and country covariates are lagged by one period. A constant term is included in all specifications, but not reported. Regressions are estimated using two-step system GMM, with collapsed instrument sets and the forward orthogonal deviations transform. Heteroskedasticity and host country correlation-robust Windmeijer-corrected standard errors are reported in parentheses. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level. The overidentification test is the Hansen J, and the AR(2) test is the Arellano-Bond first differences z.

their ability to maximize the productive efficiency of their business operations, rather than inhibiting their capacity to innovate or adopt technologies at the frontier.

We push this line of inquiry further by relaxing our baseline assumption of constant returns, and further decomposing the efficiency term into scale and pure efficiency components. The coefficient on the institutions term, reported in columns 4 and 5, indicate that the quality of governance does not operate on scale effects—thereby providing some indirect validation of our decision to hold scale constant in the

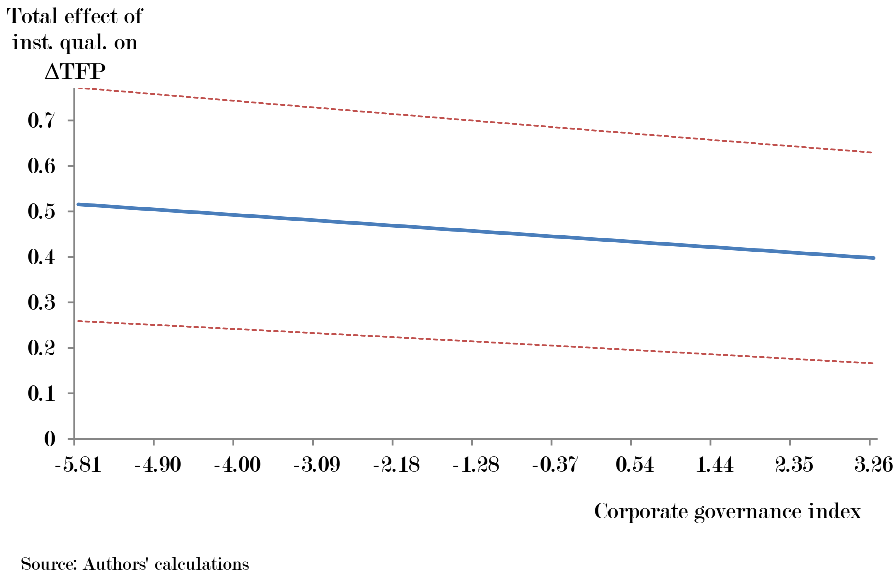

Figure 2: Total effect of institutional quality on changes in TFP, conditioned on variation in corporate governance. The dashed lines indicate the 90 percent confidence bounds. Although the relationship is decreasing in corporate governance, the total effect of institutional quality remains significantly above zero for all realizations of corporate governance.

baseline—but rather results from pure efficiency effects.[23] This result is also consistent with the broader literature, such as Girma & Görg (2007), which finds—often using entirely different empirical approaches and data—that the productivity advantages of large firms do not generally stem from their scale.

7 Do Institutions Operate on Fixed Factors?

Till now, we have focused on how institutions can affect the productivity with which variable factors of production are combined, holding fixed factors constant. In this section, we briefly consider whether institutional quality might instead condition TFP by also affecting the efficacy of fixed factors. The natural way that we approach this question is by introducing interaction terms (between institutions and fixed factors) into our baseline specification. The results for this exercise are shown in Table 10.

The two coefficients for interactions that enter with both economically and statistically significant coefficients are those on equity-to-assets (a proxy for solvency), and return on assets (a proxy for profitability). These suggest that, in addition to its direct effect on the productive efficiency of a firm's capital and labor (as shown in section 6.3), the quality of institutions may also operate by along a firm's profitability and solvency channels. For example, column 5 implies that, conditional on the firm being profitable, a one-unit improvement in the quality of a country's institutions can lead to a marginal improvement in TFP of at least another three-and-a-half times ($0.646/0.181 \approx 3.6$) over and above the direct effect of governance alone.[24] An analogous argument suggests that solvency would have a similarly positive, albeit significantly smaller, effect.

It is also worth recognizing that leverage enters with a negative (albeit marginally significant) coefficient; this is consistent with the notion that more highly-leveraged—and hence riskier—firms experience,

[23] As noted in footnote 7, a strict decomposition would require that we relax the constant-returns assumption even for the baseline. Consequently, it is best to view this particular set of results here as illustrative, rather than definitive.

[24] Alternatively, conditional on a country's institutions, a firm can expect a one-unit improvement in profitability to contribute, on average, 3.5 times as much to TFP as an otherwise unprofitable firm.

Table 9: Regressions for decomposition of change in firm productivity and institutional quality, 2006–14†

	ΔTFP **(1)**	$\Delta Tech$ **(2)**	ΔEff **(3)**	$\Delta Pure$ **(4)**	$\Delta Scale$ **(5)**
Lagged dep. change	-0.006	-1.565	0.015	-0.073	0.538
	(0.030)	(0.653)**	(0.108)	(0.081)	(0.391)
Institutional quality	0.168	-0.531	0.568	0.165	0.059
	(0.069)**	(0.445)	(0.208)***	(0.068)**	(0.126)
Firm covariates	Yes	Yes	Yes	Yes	Yes
Country covariates	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes
Wald χ^2	2,698.6***	12,203.1***	3,234.1***	2,874.0***	8,491.7***
Overid. J	18.296	1.576	14.651	18.511	8.619
AR(2) z	-1.195	-1.627	1.107	-0.217	1.148
Estimation	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM
Instruments	109	96	106	105	97
Obs.	21,695	21,695	21,695	21,695	21,695
Firms (countries)	3,446 (58)	3,446 (58)	3,446 (58)	3,446 (58)	3,446 (58)

† The dependent variable is the annual change in Malmquist firm-level TFP (column 1) and its subcomponents listed on the first row (columns 2–5). The institutional quality measure is the lagged first principal component of the six WGIs. All firm and country covariates are lagged by one period. A constant term is included in all specifications, but not reported. Regressions are estimated using two-step system GMM, with collapsed instrument sets and the forward orthogonal deviations transform. Heteroskedasticity and host country correlation-robust Windmeijer-corrected standard errors are reported in parentheses. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level. The overidentification test is the Hansen J, and the AR(2) test is the Arellano-Bond first differences z.

on average, comparatively greater declines in TFP for every marginal improvement in institutional quality.[25] We conjecture that this is because improvements in a country's overall governance is likely to be accompanied by clampdowns on excessively risky firm behavior, which would have negative spillover effects on such firms' productivity.

8 Conclusion

This paper makes the case that international variations in firm productivity—which in turn drive national economic performance—are attributable to cross-country differences in the quality of state governance institutions. This argument draws inspiration from the large literatures that imply such linkages at the aggregate level. But our study exploits cross-national firm-level data instead, which offers us additional insights into the mechanisms that drive the TFP-institutions relationship, while circumventing a number of tricky identification issues that plague more aggregate-level analyses. We find that the importance of institutional quality is remarkably robust: it survives a host of robustness checks, including alternative measures of institutions, variations to model specification, changes to time period aggregation, and the use of external instruments to address residual endogeneity concerns.

[25]The total effect of institutions, however, remains positive: evaluating at the mean for leverage, the coefficient on institutional quality is $\beta_0 + \beta_{int} \cdot \overline{LEV} = 0.194 - 0.159\,(0.242) = 0.156$, which is positive.

Table 10: Regressions for change in firm productivity and institutional quality interacted with fixed firm factors, 2006–14†

	(1)	(2)	(3)	(4)	(5)
Lagged TFP	0.045	0.118	0.039	-0.003	0.019
	(0.051)	(0.063)*	(0.040)	(0.037)	(0.039)
Institutional	0.232	0.072	-0.066	0.194	0.181
quality	(0.220)	(0.074)	(0.079)	(0.090)**	(0.099)*
Institutions ×	0.009				
assets	(0.013)				
Institutions ×		0.012			
MTB		(0.019)			
Institutions ×			0.221		
ETA			(0.083)***		
Institutions ×				-0.159	
leverage				(0.082)*	
Institutions ×					0.646
ROA					(0.217)***
Firm covariates	Yes	Yes	Yes	Yes	Yes
Country covariates	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes
Wald χ^2	2,125.0***	7,727.3***	2,464.9***	1,254.5***	1,083.4***
Overid. J	9.627	10.961	17.020	11.325	23.854
AR(2) z	-0.011	1.209	0.173	-1.109	-0.559
Estimation	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM
Instruments	105	100	107	107	113
Obs.	21,695	21,695	21,695	21,695	21,695
Firms (countries)	3,446 (58)	3,446 (58)	3,446 (58)	3,446 (58)	3,446 (58)

† The dependent variable is the annual change in Malmquist firm-level TFP. The institutional quality measure is the lagged first principal component of the six WGIs. All firm and country covariates are lagged by one period. The respective uninteracted firm covariate, and a constant term, are included in all specifications, but not reported. Regressions are estimated using two-step system GMM, with collapsed instrument sets and the forward orthogonal deviations transform. Heteroskedasticity and host country correlation-robust Windmeijer-corrected standard errors are reported in parentheses. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level. The overidentification test is the Hansen J, and the AR(2) test is the Arellano-Bond first differences z.

Although we have sought to be as thorough as possible in our empirical analysis, a number of shortcomings—mainly related to data limitations—present themselves as areas for future research. While we have relied on DEA techniques to obtain our measure of Malmquist TFP—for reasons documented in the text—an alternative approach to computing TFP, such as that of Levinsohn & Petrin (2003) or stochastic frontiers, would serve as a useful check. In addition, we view our exploration of the relationship between corporate and state governance in section 6.2 as only scratching the surface of the many intriguing linkages in the relationship between the two. Finally, it would be interesting to explore how other "fundamental" drivers of long-term growth (Acemoğlu *et al.* 2005), such as geography and social capital, come into play with regard to their effects on firm-level TFP.

References

Acemoğlu, K. Daron & Simon Johnson (2005). "Unbundling Institutions". *Journal of Political Economy* 113(5) (October): 949–995

Acemoğlu, K. Daron, Simon Johnson & James A. Robinson (2005). "Institutions as a Fundamental Cause of Long-Run Economic Growth". In Philippe M. Aghion & Steven N. Durlauf (editors), *Handbook of Economic Growth*, volume 1, pp. 385–472. Amsterdam, The Netherlands: Elsevier

Aigner, Dennis J., C.A. Knox Lovell & Peter J. Schmidt (1977). "Formulation and Estimation of Stochastic Frontier Production Function Models". *Journal of Econometrics* 6(1) (July): 21–37

Alesina, Alberto F., William R. Easterly, Arnaud Devleeschauwer, Sergio A. Kurlat & Romain T. Wacziarg (2003). "Fractionalization". *Journal of Economic Growth* 8(2) (June): 155–194

Anderson, Terry L. & Dean Lueck (1992). "Land Tenure and Agricultural Productivity on Indian Reservations". *Journal of Law and Economics* 35(2) (October): 427–454

Anós-Casero, Paloma & Charles C. Udomsaph (2009). "What Drives Firm Productivity Growth?" *World Bank Policy Research Working Paper* 4841, Washington, DC: The World Bank

Arellano, Manuel (2016). "Modelling Optimal Instrumental Variables for Dynamic Panel Data Models". *Research in Economics* 70(2) (June): 238–261

Arellano, Manuel & Olympia Bover (1995). "Another Look at the Instrumental Variable Estimation of Error-Components Models". *Journal of Econometrics* 68(1) (July): 29–51

Arnold, Jens Matthias, Aaditya Mattoo & Gaia Narciso (2008). "Services Inputs and Firm Productivity in Sub-Saharan Africa: Evidence from Firm-Level Data". *Journal of African Economies* 17(4) (August): 578–599

Augier, Patricia, Marion Dovis & Michael Gasiorek (2012). "The Business Environment and Moroccan Firm Productivity". *Economics of Transition* 20(2) (April): 369–399

Banerjee, Abhijit V. & Lakshmi Iyer (2005). "History, Institutions, and Economic Performance: The Legacy of Colonial Land Tenure Systems in India". *American Economic Review* 95(4) (September): 1190–1213

Barro, Robert J. (1999). "Notes on Growth Accounting". *Journal of Economic Growth* 4(2) (June): 119–137

Bartelsman, Eric J., John C. Haltiwanger & Stefano Scarpetta (2010). "Cross-Country and Within-Country Differences in the Business Climate". *International Journal of Industrial Organization* 28(4) (July): 368–371

Bartelsman, Eric J., John C. Haltiwanger & Stefano Scarpetta (2013). "Cross-Country Differences in Productivity: The Role of Allocation and Selection". *American Economic Review* 103(1) (February): 305–334

Barth, Erling, Trygve Gulbrandsen & Pål Schønea (2005). "Family Ownership and Productivity: The Role of Owner-Management". *Journal of Corporate Finance* 11(1-2) (March): 107–127

Benhabib, Jess & Mark M. Spiegel (2000). "The Role of Financial Development in Growth and Investment". *Journal of Economic Growth* 5(4) (December): 341–360

Bernard, Andrew B., J. Bradford Jensen, Stephen J. Redding & Peter K. Schott (2012). "The Empirics of Firm Heterogeneity and International Trade". *Annual Review of Economics* 4(1) (July): 283–313

Bjurek, Hans (1996). "The Malmquist Total Factor Productivity Index". *Scandinavian Journal of Economics* 98(2) (June): 303–313

Blundell, Richard & Stephen R. Bond (1998). "Initial Conditions and Moment Restrictions in Dynamic Panel Data Models". *Journal of Econometrics* 87(1) (August): 115–143

Cai, Hongbin, Hanming Fang & Lixin Colin Xu (2011). "Eat, Drink, Firms, Government: An Investigation of Corruption from the Entertainment and Travel Costs of Chinese Firms". *Journal of Law and Economics* 54(1) (February): 55–78

Caselli, Francesco (2005). "Accounting for Income Differences Across Countries". In Philippe M. Aghion & Steven N. Durlauf (editors), *Handbook of Economic Growth*, volume 1, chapter 9, pp. 679–741. Amsterdam, The Netherlands: Elsevier

Caves, Douglas W., Laurits R. Christensen & W. Erwin Diewert (1982). "The Economic Theory of Index Numbers and the Measurement of Input, Output, and Productivity". *Econometrica* 50(6) (November): 1392–1414

Charnes, Abraham, William W. Cooper & Edwardo L. Rhodes (1978). "Measuring the Efficiency of Decision Making Units". *European Journal of Operational Research* 2(6) (November): 429–444

Chiang, Min-Hsien & Jia-Hui Lin (2007). "The Relationship between Corporate Governance and Firm Productivity: evidence from Taiwan's manufacturing firms". *Corporate Governance: An International Review* 15(5) (September): 768–779

Chinn, Menzie D. & Hiro Ito (2008). "A New Measure of Financial Openness". *Journal of Comparative Policy Analysis* 10(3) (September): 309–322

Clerides, Sofronis K., Saul Lach & James R. Tybout (1998). "Is Learning By Exporting Important? Micro-Dynamic Evidence From Colombia, Mexico, And Morocco". *Quarterly Journal of Economics* 113(3) (August): 903–947

Comin, Diego A., Bart Hobijn & Emilie Rovito (2008). "Technology Usage Lags". *Journal of Economic Growth* 13(4) (December): 237–256

Davis, Donald R. & David E. Weinstein (2001). "An Account of Global Factor Trade". *American Economic Review* 91(5) (December): 1423–1453

Dollar, David, Mary C. Hallward-Driemeier & Taye A. Mengistae (2005). "Investment Climate and Firm Performance in Developing Economies". *Economic Development and Cultural Change* 54(1) (October): 1–31

Dyson, Robert G., Rachel Allen, Ana S. Camanho, Victor V. Podinovski, Cláudia S. Sarrico & Estelle A. Shale (2001). "Pitfalls and Protocols in DEA". *European Journal of Operational Research* 132(2) (July): 245–259

Eifert, Benn, Alan H. Gelb & Vijaya Ramachandran (2008). "The Cost of Doing Business in Africa: Evidence from Enterprise Survey Data". *World Development* 36(9) (September): 1531–1546

Färe, Rolf & Shawna P. Grosskopf (2004). *New Directions: Efficiency and Productivity*, volume 3 of *Studies in Productivity and Efficiency*. Boston, MA: Kluwer Academic

Färe, Rolf, Shawna P. Grosskopf & C.A. Knox Lovell (1994a). *Production Frontiers*. Cambridge, England: Cambridge University Press

Färe, Rolf, Shawna P. Grosskopf, Mary E. Norris & Zhongyang Zhang (1994b). "Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries". *American Economic Review* 84(1) (March): 66–83

Farrell, Michael J. (1957). "The Measurement of Productive Efficiency". *Journal of the Royal Statistical Society Series A* 120(3) (July): 253–290

Galiani, Sebastian & Ernesto Schargrodsky (2011). "Land Property Rights and Resource Allocation". *Journal of Law and Economics* 54(S4) (November): S329–S345

Galindo, Arturo J., Fabio Schiantarelli & Andrew M. Weiss (2007). "Does Financial Liberalization Improve the Allocation of Investment?: Micro-Evidence from Developing Countries". *Journal of Development Economics* 83(2) (July): 562–587

Girma, Sourafel & Holger Görg (2007). "Multinationals' Productivity Advantage: Scale or Technology?" *Economic Inquiry* 45(2) (April): 350–362

Grafton, R. Quentin, Dale Squires & Kevin J. Fox (2000). "Private Property and Economic Efficiency: A Study of a Common-Pool Resource". *Journal of Law and Economics* 43(2) (October): 679–714

Grifell-Tatjé, Emili & C.A. Knox Lovell (1995). "A Note on the Malmquist Productivity Index". *Economics Letters* 47(2) (February): 169–175

Griliches, H. Zvi & Jacques Mairesse (1998). "Production Functions: The Search for Identification". In Steinar Strøm (editor), *Econometrics and Economic Theory in the Twentieth Century: The Ragnar Frisch Centennial Symposium*, pp. 169–203. Cambridge, England: Cambridge University Press

Hall, Robert E. & Charles I. Jones (1999). "Why Do Some Countries Produce So Much More Output Per Worker Than Others?" *Quarterly Journal of Economics* 114(1) (February): 83–116

Haltiwanger, John C., Stefano Scarpetta & Helena Schweiger (2014). "Assessing Job Flows Across Countries: The Role of Industry, Firm Size, and Regulations". *Labour Economics* 26(1) (January): 11–25

Harrison, Ann E., Justin Yifu Lin & Lixin Colin Xu (2014). "Explaining Africa's (Dis)advantage". *World Development* 63(1) (November): 59–77

Hsieh, Chang-Tai & Peter J. Klenow (2009). "Misallocation and Manufacturing TFP in China and India". *Quarterly Journal of Economics* 124(4) (November): 1403–1448

Hsieh, Chang-Tai & Peter J. Klenow (2010). "Development Accounting". *American Economic Journal: Macroeconomics* 2(1) (January): 207–223

Kaufmann, Daniel, Aart C. Kraay & Massimo Mastruzzi (2011). "The Worldwide Governance Indicators: Methodology and Analytical Issues". *Hague Journal on the Rule of Law* 3(2) (September): 220–246

Keller, Wolfgang & Stephen R Yeaple (2009). “Multinational Enterprises, International Trade, and Productivity Growth: Firm-Level Evidence from the United States”. *Review of Economics and Statistics* 91(4) (November): 821–831

Köke, Jens & Luc Renneboog (2005). “Do Corporate Control and Product Market Competition Lead to Stronger Productivity Growth? Evidence from Market-Oriented and Blockholder-Based Governance Regimes”. *Journal of Law and Economics* 48(2) (October): 475–516

La Porta, Rafael, Florencio López-de Silanes, Andrei Shleifer & Robert W. Vishny (1998). “Law and Finance”. *Journal of Political Economy* 106(6) (December): 1113–1155

Levinsohn, James A. & Amil K. Petrin (2003). “Estimating Production Functions Using Inputs to Control for Unobservables”. *Review of Economic Studies* 70(2) (April): 317–341

Liu, Xiaming, Pamela A. Siler, Chengqi Wang & Yingqi Wei (2000). “Productivity Spillovers From Foreign Direct Investment: Evidence From UK Industry Level Panel Data”. *Journal of International Business Studies* 31(3) (September): 407–425

Margaritis, Dimitris & Maria Psillaki (2010). “Capital Structure, Equity Ownership and Firm Performance”. *Journal of Banking and Finance* 34(3) (March): 621–632

McGowan, Müge Adale, Dan Andrews, Chiara Criscuolo & Giuseppe Nicoletti (2015). *The Future of Productivity.* Paris, France: Organisation for Economic Co-operation and Development

McMillan, Margaret S. & Dani Rodrik (2011). “Globalization, Structural Change and Productivity Growth”. In Marc Bacchetta & Marion Jansen (editors), *Making Globalization Socially Sustainable*, pp. 49–84. Geneva Switzerland: International Labor Organization

Meeusen, Wim & Julien van den Broeck (1977). “Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error”. *International Economic Review* 18(2) (June): 435–444

Mefford, Robert N. (1986). “Determinants of Productivity Differences in International Manufacturing”. *Journal of International Business Studies* 17(1) (March): 63–82

Melitz, Marc J. (2003). “The Impact of Trade on Intra-Industry Allocations and Aggregate Industry Productivity”. *Econometrica* 71(6) (November): 1695–1725

Meyer, Klaus E. & Sinani. Evis (2009). “When and Where Does Foreign Direct Investment Generate Positive Spillovers? A Meta-Analysis”. *Journal of International Business Studies* 40(7) (September): 1075–1094

Muendler, Marc-Andreas (2004). “Trade, Technology, and Productivity: A Study of Brazilian Manufacturers, 1986–1998”. *CESifo Working Paper Series* 1148, Munich, Germany: CESifo Group

Nickell, Stephen J. (1981). “Biases in Dynamic Models with Fixed Effects”. *Econometrica* 49(6) (November): 1417–1426

Nicoletti, Giuseppe & Stefano Scarpetta (2003). “Regulation, Productivity and Growth: OECD Evidence”. *Economic Policy* 18(36) (April): 9–72

North, Douglass C. (1990). *Institutions, Institutional Change and Economic Performance.* Cambridge, England: Cambridge University Press

Olley, G. Steven & Ariel S. Pakes (1996). “The Dynamics of Productivity in the Telecommunications Equipment Industry”. *Econometrica* 64(6) (November): 1263–1297

Olney, William W. (2016). “Impact of Corruption on Firm-Level Export Decisions”. *Economic Inquiry* 54(2) (April): 1105–1127

Parente, Paulo M.D.C. & João M.C. Santos Silva (2012). “A Cautionary Note on Tests of Overidentifying Restrictions”. *Economics Letters* 115(2) (May): 314–317

Pavcnik, Nina (2002). “Trade Liberalization, Exit, and Productivity Improvement: Evidence from Chilean Plants”. *Review of Economic Studies* 69(1) (January): 245–276

Petrin, Amil K. & Jagadeesh Sivadasan (2013). “Estimating Lost Output from Allocative Inefficiency, with an Application to Chile and Firing Costs”. *Review of Economics and Statistics* 95(1) (March): 286–301

Ray, Subhash C. & Evangelia Desli (1997). “Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries: Comment”. *American Economic Review* 87(5) (December): 1033–1039

Rivera-Batiz, Francisco L. (2002). “Democracy, Governance, and Economic Growth: Theory and Evidence”. *Review of Development Economics* 6(2) (June): 225–247

Rodrik, Dani, Arvind Subramanian & Francesco Trebbi (2004). “Institutions Rule: The Primacy of Institutions over Geography and Integration in Economic Development”. *Journal of Economic Growth* 9(2) (June): 131–165

Roodman, David M. (2009). "A Note on the Theme of Too Many Instruments". *Oxford Bulletin of Economics and Statistics* 71(1) (February): 135–158

Scarpetta, Stefano, Philip J. Hemmings, Thierry Tressel & Jaejoon Woo (2002). "The Role of Policy and Institutions for Productivity and Firm Dynamics: Evidence from Micro and Industry Data". *OECD Economics Department Working Paper* 329, Paris, France: Organisation for Economic Co-operation and Development

Shleifer, Andrei & Robert W Vishny (1997). "A Survey of Corporate Governance". *Journal of Finance* 53(2) (June): 737–783

Solarin, Sakiru Adebola (2015). "Testing for the Stationarity in Total Factor Productivity: Nonlinearity Evidence from 79 Countries". *Journal of the Knowledge Economy* pp. 1–18

Solow, Robert M. (1956). "A Contribution to the Theory of Economic Growth". *Quarterly Journal of Economics* 70(1) (February): 65–94

Syverson, Chad W. (2004). "Market Structure and Productivity: A Concrete Example". *Journal of Political Economy* 112(6) (December): 1181–1222

Syverson, Chad W. (2011). "What Determines Productivity?" *Journal of Economic Literature* 49(2) (June): 326–365

Teulings, Coen N. & Richard E. Baldwin (editors) (2014). *Secular Stagnation: Facts, Causes and Cures*. London, England: Centre for Economic Policy Research Press

van Ark, Bart H.H. (1995). "Manufacturing Prices, Productivity, and Labor Costs in Five Economies". *Monthly Labor Review* 22(7) (July): 56–72

van Biesebroeck, Johannes (2005). "Firm Size Matters: Growth and Productivity Growth in African Manufacturing". *Economic Development and Cultural Change* 53(3) (April): 545–583

van Biesebroeck, Johannes (2007). "Robustness of Productivity Estimates". *Journal of Industrial Economics* 55(3) (September): 529–569

Wildau, Gabriel (2016). "Chinas State-Owned Zombie Economy". *Financial Times* (March 1): 9

Williamson, Claudia R. & Carrie B. Kerekes (2011). "Securing Private Property: Formal versus Informal Institutions". *Journal of Law and Economics* 54(3) (August): 537–572

Technical Appendix

A.1 Additional tables

Table A.1: Baseline sample of economies[†]

	Advanced	
Australia	Iceland	Singapore
Austria	Ireland	Slovak Republic
Belgium	Italy	Slovenia
Canada	Japan	Spain
Denmark	Latvia	Sweden
Finland	Lithuania	Switzerland
France	Netherlands	United Kingdom
Germany	New Zealand	United States
Greece	Norway	
Hong Kong	Portugal	
	Developing	
Bangladesh	India	Peru
Bosnia-Herzegovina	Indonesia	Philippines
Brazil	Israel	Poland
Bulgaria	Kenya	Romania
Chile	Malaysia	Russian Federation
China	Mauritius	South Africa
Croatia	Mexico	Sri Lanka
Czech Republic	Nigeria	Thailand
Ghana	Oman	Turkey
Hungary	Pakistan	Vietnam

[†] The baseline sample is the largest available sample for the baseline.

Table A.2: Summary statistics for main variables in baseline[†]

	N	Mean	Std. Dev.	Min	Max
Change in TFP	21,695	1.054	0.434	0.025	35.444
Institutional quality	21,695	0.029	2.258	-5.811	3.259
Assets	21,695	13.186	1.580	8.183	18.048
Market-to-book	21,695	1.420	0.885	0.452	14.644
Equity-to-assets	21,695	0.465	0.170	0.047	0.951
Leverage	21,695	0.240	0.152	0.000	0.908
Return on assets	21,695	0.032	0.070	-0.750	0.299
GDP per capita	21,695	10.142	0.740	7.779	11.261
Financial development	21,695	140.538	51.036	11.541	272.936
Trade openness	21,695	61.192	70.359	22.106	455.277
Financial openness	21,695	0.788	0.349	0	1

[†] Summary statistics are provided for the full sample available for the period 2006–2014.

Table A.3: Correlation matrix for main variables of interest

	Change TFP	IQ (WGI)	IQ (DB)	IQ (GCR)	Assets	MTB	ETA	Lev	ROA	GDP per cap	Fin dev	Trade open	Fin open
Change in TFP	1.00												
Institutional quality (WGI)	0.99	1.00											
Institutional quality (DB)	0.06	0.01	1.00										
Institutional quality (GCR)	-0.10	-0.09	-0.03	1.00									
Assets	-0.29	-0.33	0.13	-0.11	1.00								
Market-to-book	0.30	0.32	0.05	0.08	0.16	1.00							
Equity-to-assets	0.59	0.58	0.05	-0.12	0.17	0.41	1.00						
Leverage	0.57	0.56	0.07	-0.19	0.04	0.23	0.42	1.00					
ROA	0.30	0.29	0.25	0.01	0.32	0.48	0.48	0.34	1.00				
GDP per capita	0.27	0.28	-0.05	0.09	-0.25	0.14	-0.03	0.07	-0.20	1.00			
Financial development	0.37	0.38	-0.05	-0.05	0.18	0.33	0.56	0.25	0.35	-0.02	1.00		
Trade openness	0.34	0.36	-0.11	0.01	0.00	0.42	0.38	0.08	0.38	-0.01	0.45	1.00	
Financial openness	0.34	0.36	-0.11	0.01	0.00	0.42	0.38	0.08	0.38	-0.01	0.45	0.45	1.00

Table A.4: Sources and definitions for main variables of interest†

Variable	Definition	Source
Change in TFP	Change in Malmquist firm-level TFP	Authors' calculations, using Worldscope
Institutional quality	First principal component of 6 component WGI indicators	Authors' calculations, using WGI
Institutional quality (DB)	First principal component of 4 component DB indicators	Authors' calculations, using DB
Institutional quality (GCR)	First principal component of 8 component GCR indicators	Authors' calculations, using GCR
Corporate governance	First principal component of 5 component GCR indicators	Authors' calculations, using GCR
	Firm covariates	
Assets	Total firm assets	Worldscope
Market-to-book	Book value of assets less equity plus market value of equity, over book value of assets	Worldscope
Equity-to-assets	Ratio of total equity to total assets	Worldscope
Leverage	Ratio of debt (short plus long-term) to total assets	Worldscope
Return to assets	Net income before extraordinary items/preferred dividends over total assets	Worldscope
	Country covariates	
GDP per capita	Real gross domestic product in 2010 USD divided by total population	WDI
Financial development	Domestic credit to the private sector as share of GDP	WDI
Trade openness	Imports plus exports divided by GDP	WDI
Financial openness	Index of capital account openness	Chinn & Ito (2008)

† DB = Doing Business, GCR = Global Competitiveness Report, WDI = World Development Indicators, WGI = World Governance Indicators.

Table A.5: Regressions for change in firm productivity and alternative institutional quality measure (Economic Freedom Index), 2006–14†

	Econ freedom (1)	*Prop rights* (2)	*Corruption* (3)	*Biz freedom* (4)	*Labor freedom* (5)	*Invest freedom* (6)
Lagged TFP	-0.033	-0.029	-0.636	-0.003	-0.571	-0.549
change	(0.036)	(0.040)	(0.391)	(0.025)	(0.382)	(0.347)
Institutional	0.159	0.008	0.006	0.005	0.004	0.003
quality (EFI)	(0.057)***	(0.002)***	(0.003)**	(0.002)***	(0.002)*	(0.001)***
Firm covariates	Yes	Yes	Yes	Yes	Yes	Yes
Country covariates	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Wald χ^2	38,690.0***	45,925.0***	135,175.8***	35,739.5***	14,095.8***	68,893.7***
Overid. J	4.646	11.052	12.198	13.949	13.881	17.304
AR(2) z	-1.325	-1.437	-1.412	-0.784	-1.286	-1.314
Estimation	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM
Instruments	96	101	103	101	103	103
Obs.	19,669	19,669	19,669	19,669	19,669	19,669
Firms (countries)	3,444 (58)	3,444 (58)	3,444 (58)	3,444 (58)	3,444 (58)	3,444 (58)

† The dependent variable is the annual change in Malmquist firm-level TFP. The institutional quality measure is the lagged first principal component of five selected state governance-related EFI measures (column 1), and the lagged value for each of the five EFIs (property rights, freedom from corruption, business freedom, labor freedom, investment freedom) listed on the first row (columns 2–6). All firm and country covariates are lagged by one period. A constant term is included in all specifications, but not reported. Regressions are estimated using two-step system GMM, with collapsed instrument sets and the forward orthogonal deviations transform. Heteroskedasticity and host country correlation-robust Windmeijer-corrected standard errors are reported in parentheses. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level. The overidentification test is the Hansen J, and the AR(2) test is the Arellano-Bond first differences z.

A.2 Additional figures

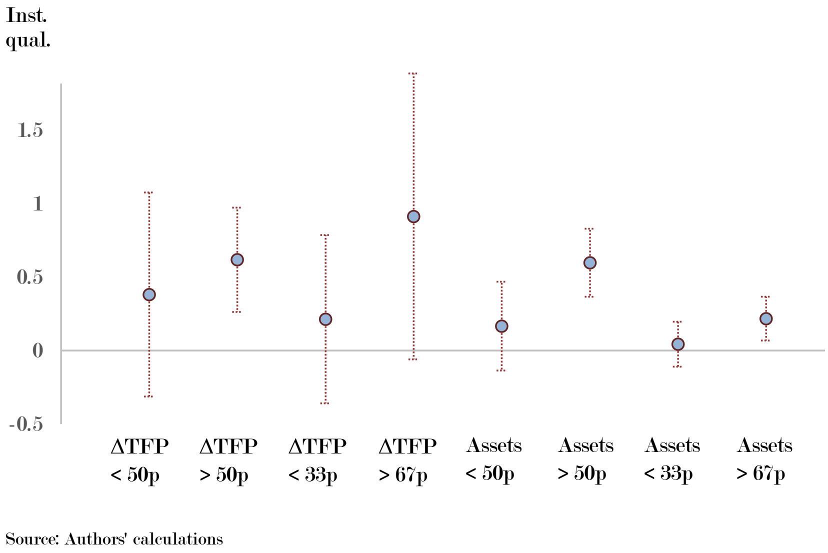

Figure A.1: Plot of coefficients for institutional quality with 90 percent error bands for various subsamples, sorted by percentile of change in TFP or assets. It is clear that, by and large, it is the upper end of the distribution of both that is driving the significant coefficients, and that this effect diminishes as one moves to the left of the distribution.

A.3 Data Envelopment Analysis

This appendix provides a high-level discussion of the linear programming procedure known as data envelopment analysis (DEA), with a focus on the aspects of DEA most relevant to our application: input- versus output-based DEA, the returns to scale assumption, the computation of the Malmquist productivity index using DEA subject to our specific assumptions, and the decomposition of said index into technical versus productive efficiency changes. Detailed treatments of DEA and Malmquist productivity are available in, *inter alia*, Färe *et al.* (1994a) and Färe & Grosskopf (2004).

Consider a vector of input quantities, $\mathbf{x} = [x_1, \ldots, x_m] \in \Re^+_m$, that are transformed via a production technology into quantities of output, given by the vector $\mathbf{y} = [y_1, \ldots, y_n] \in \Re^+_n$. For a given period t, the production set $\mathbf{P}$ of all possible input-output combinations is thus defined as

$$\mathbf{P}_t = \left\{ (\mathbf{x}_t, \mathbf{y}_t) \in \Re^+_{m+n} : \mathbf{y}_t \text{ feasible } \forall\, \mathbf{x}_t \in t \right\}. \tag{A.1}$$

The production technology (A.1) is further assumed to satisfy a number of standard technical axioms, including those for inaction, boundedness, closedness, and strong disposability. For our application, we further assume convexity of $\mathbf{P}_t$ and, importantly,

$$\sigma \mathbf{P}_t \subseteq \mathbf{P}_t \; \forall\, \sigma > 0,$$

which imposes constant returns to scale. This assumption is crucial, because under variable returns to scale, productivity changes in a traditional Malmquist index would not generally coincide with changes in TFP (Grifell-Tatjé & Lovell 1995). The evaluation of efficiency is based on computing Farrell (1957) input efficiency, which is the minimum contraction of the vector $\mathbf{x}$ by a scalar θ while remaining on the technological boundary:[26]

$$\mathbf{E}_t\left(\mathbf{x}_t, \mathbf{y}_t\right) = \inf_{\theta} \left\{ \theta^{-1} : (\theta \mathbf{x}_t, \mathbf{y}_t) \in \mathbf{P}_t, \theta \geq 0 \right\}. \tag{A.2}$$

Our convexity assumption—along with the nonstrict specification of the inequality in (A.2)—allows us to apply linear programming methods to solve (A.2). In particular, DEA is applied to solve, for a given firm (or DMU) f, the problem

$$\begin{aligned} \min_{\theta,\lambda} \frac{1}{\theta} \quad \text{s.t.} \quad & \sum_{i=1}^{m} \lambda x_{i,f} \leq \theta x_f \\ & \sum_{j=1}^{n} \lambda y_{j,f} \geq y_f \\ & \sum_{f=1}^{F} \lambda_f = 1, \; \mathbf{\Lambda} \geq 0, \end{aligned} \tag{A.3}$$

where $\theta \in \Re$ is a (scalar) distance measure and $\mathbf{\Lambda} = [\lambda_1, \ldots, \lambda_F]$ is a semipositive weighting vector in $\Re_F$. Note that the constant returns assumption appears explicitly as the penultimate constraint in (A.3).

The solution to (A.3) can then be expressed as the distance function (A.2) for any given period; for instance, the (input-based) Malmquist productivity index is calculated relative to base period t as:

$$\mathbf{M}_t\left(\mathbf{x}_t, \mathbf{x}_{t+1}, \mathbf{y}_t, \mathbf{y}_{t+1}\right) = \frac{\mathbf{E}_t\left(\mathbf{x}_{t+1}, \mathbf{y}_{t+1}\right)}{\mathbf{E}_t\left(\mathbf{x}_t, \mathbf{y}_t\right)}. \tag{A.4}$$

In order to avoid the arbitrary selection of a base year, it is standard practice to take the geometric mean of the index evaluated at either base year to obtain

$$\overline{\mathbf{M}} = \left[\mathbf{M}_t \cdot \mathbf{M}_{t+1}\right]^{\frac{1}{2}}, \tag{A.5}$$

[26] It is also possible to compute an output-based efficiency measure, which is given by $\mathbf{E}'_t\left(\mathbf{x}_t, \mathbf{y}_t\right) = \sup_{\lambda} \left\{ \lambda : (\mathbf{x}_t, \lambda \mathbf{y}_t) \in \mathbf{P}_t, \lambda \geq 1 \right\}$. This would yield analogous output-based Malmquist productivity indexes.

which is a base-invariant measure. In addition to avoiding the arbitrary selection of a base year, using the geometric average (A.5) along with the constant returns assumption allows us to interpret changes in the index (A.5) as corresponding to changes in TFP (Bjurek 1996).[27]

Multiplying (A.5) through by the expressions $[\mathbf{E}_{t+1}(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})/\mathbf{E}_{t+1}(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})]^{\frac{1}{2}}$ and $[\mathbf{E}_t(\mathbf{x}_t, \mathbf{y}_t)/\mathbf{E}_t(\mathbf{x}_t, \mathbf{y}_t)]^{\frac{1}{2}}$, and rearranging, we obtain the decomposition:

$$\begin{aligned}\overline{\mathbf{M}} &= \left[\frac{\mathbf{E}_t(\mathbf{x}_t, \mathbf{y}_t)}{\mathbf{E}_{t+1}(\mathbf{x}_t, \mathbf{y}_t)} \cdot \frac{\mathbf{E}_t(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})}{\mathbf{E}_{t+1}(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})}\right]^{\frac{1}{2}} \cdot \left[\frac{\mathbf{E}_{t+1}(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})}{\mathbf{E}_t(\mathbf{x}_t, \mathbf{y}_t)}\right] \\ &= \Delta\mathbf{Eff} \cdot \Delta\mathbf{Tech},\end{aligned} \tag{A.6}$$

where Δ**Tech** and Δ**Eff** are the (input-based) changes in technology and efficiency, respectively. It is well-understood that if we relax the assumption of constant returns, it is possible to further decompose $\Delta Tech$ into changes attributable purely to technical and scale efficiency (Färe *et al.* 1994b). Although this means that changes in the Malmquist index can no longer be interpreted as changes to TFP, this additional decomposition is illustrative of the relative contributions of changes to (Malmquist) productivity attributable to either scale effects or pure efficiency:

$$\begin{aligned}\overline{\mathbf{M}} &= \left[\frac{\tilde{\mathbf{E}}_{t+1}(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})/\bar{\mathbf{E}}_{t+1}(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})}{\tilde{\mathbf{E}}_{t+1}(\mathbf{x}_t, \mathbf{y}_t)/\bar{\mathbf{E}}_{t+1}(\mathbf{x}_t, \mathbf{y}_t)} \cdot \frac{\tilde{\mathbf{E}}_t(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})/\bar{\mathbf{E}}_t(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})}{\tilde{\mathbf{E}}_t(\mathbf{x}_t, \mathbf{y}_t)/\bar{\mathbf{E}}_t(\mathbf{x}_t, \mathbf{y}_t)}\right]^{\frac{1}{2}} \cdot \\ &\quad \left[\frac{\tilde{\mathbf{E}}_{t+1}(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})}{\tilde{\mathbf{E}}_t(\mathbf{x}_t, \mathbf{y}_t)}\right] \cdot \left[\frac{\mathbf{E}_{t+1}(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})}{\mathbf{E}_t(\mathbf{x}_t, \mathbf{y}_t)}\right] \\ &= \Delta\mathbf{Scale} \cdot \Delta\mathbf{Pure} \cdot \Delta\mathbf{Tech},\end{aligned} \tag{A.7}$$

where $\bar{\mathbf{E}}$ and $\tilde{\mathbf{E}}$ represent, respectively, the distance functions computed from DEA frontiers under constant and variable returns to scale, and Δ**Scale** and Δ**Pure** are changes in efficiency due to economies of scale and pure efficiency gains, respectively. As Ray & Desli (1997) note, internal consistency requires that this additional decomposition be performed only after imposing variable returns in (A.3). Since our central concern is to preserve the TFP interpretation of our productivity measure, we consider this secondary decomposition only to the extent that it provides some additional (if slightly inconsistent) insight into which productivity components are influenced by institutional quality.

[27] More precisely, Bjurek (1996) demonstrates that a total factor productivity index—computed as the ratio of the output-based to input-based Malmquist indexes—will coincide with (A.5) in the presence of constant returns technology (as well as be inversely homothetic).