Do Infrastructure Reforms Reduce the Effect of Corruption? Theory and Evidence from Latin America and the Caribbean.

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Do infrastructure reforms reduce the effect of corruption? Theory and evidence from Latin America and the Caribbean *

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Abstract

This paper investigates the interaction between corruption and infrastructure policy reforms. I construct a simple model to illustrate how both an increase in regulatory autonomy and privatisation may influence the effect of corruption. This interaction is then analysed empirically using a panel of 153 electricity distribution firms across 18 countries in Latin America and the Caribbean between 1995 and 2007. I find evidence that greater corruption is associated with lower firm efficiency, but that this association is reduced when an independent regulatory agency is present. These results survive a range of robustness checks including instrumenting for regulatory governance and corruption. I also find slightly less robust evidence that private ownership further mitigates the association between corruption and efficiency.

1 Introduction

Corruption has been identified as a key factor that may reduce growth and worsen poverty (Lambsdorff, 2005; Svensson, 2005; Fisman and Svensson, 2007). One area of the economy particularly vulnerable to corruption is the operation and regulation of network infrastructure, where a high level of government intervention and frequent lack of competition favour corruption (Dal Bó, 2006; Estache and Trujillo, 2009; Kenny, 2009). Practitioners and reserchers have therefore become increasingly interested in ways of reducing the impact of corruption on these sectors (Estache and Wren-Lewis, 2011). However, little evidence exists on whether major sectoral reforms implemented have had a significant influence on the effects of corruption.

Two important aspects of reform have been privatisation and an increase in bureaucratic autonomy through the creation of independent regulatory agencies (IRAs). This paper analyses the impact of these reforms with particular regard to how they interact with national corruption levels. I build a simple model to demonstrate how ownership and regulatory autonomy may influence the effects of corrupt behaviour. The resulting propositions are then analysed empirically by considering the efficiency of electricity distribution firms in Latin America and the Caribbean (LAC) over the period 1995 to 2007.

A number of previous studies have focused on the effect of corruption on infrastructure performance. Closest to the work of this paper is that of Dal Bó and Rossi (2007), who find corruption to be associated

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with inefficiency amongst electricity distribution firms in Latin America. They however do not focus on how this association interacts with regulation and privatisation, partly due to a lack of data on regulatory governance.[1] Another set of papers have used recently collected data on regulatory governance to consider the impact of regulatory reforms in more detail.[2] In particular, Andres, Azumendi and Guasch (2008) produce evidence that better regulatory governance and privatisation increase the efficiency of electricity distribution firms in LAC.[3] However, they do not consider the role of corruption.

The main contribution of this paper is therefore to evaluate how the impacts of IRA creation and privatisation are related to corruption. The question is empirically interesting since theoretically the interaction of corruption with these reforms is not straightforward (Boehm, 2009; Martimort and Straub, 2009). Indeed, the paper sets out a simple model that demonstrates how regulatory autonomy may either worsen or strengthen the negative effect of corruption on efficiency.

Overall, the empirical analysis suggests that regulation by an IRA and private ownership significantly reduce the association between corruption and inefficiency. Indeed, variations in countries' corruption levels appear to explain a substantial proportion of the heterogeneity in the effects of each of these reforms.

The analysis makes use of annual firm-level data on 153 electricity distribution firms across 18 countries along with detailed measures their respective IRA's governance. In order to control for time-invarient omitted variables, the regressions use a firm fixed effects model. I show that the main results are robust to a range of permutations including allowing for firm-specific corruption effects and including a large range of additional control variables. Moreover, the negative association of corruption with efficiency and the mitigating impact of an IRA are robust to instrumenting individually for corruption and regulatory governance. These results also remain when using two alternative corruption measures, one based on firm surveys and the other observed corruption in Brazil. On the other hand, the interaction between corruption and private ownership appears somewhat less robust, with the relevant coefficient losing significance when ownership is instrumented for and other corruption measures are used.

The paper proceeds as follows. In the following section, I build a simple model to illustrate how corruption, privatisation and the regulatory structure may interact in their effect on labour efficiency. In this model, regulatory autonomy decreases the ability of corruptible politicians to interfere in the regulatory process, but increases the freedom of corruptible regulators. Privatisation works through a different mechanism, by reducing the proportion of corrupt proceeds that are used to inefficiently over-employ. In Section 3 I then describe the data and outline the empirical methodology that I use, which is based on estimating a labour demand function. The results are analysed in Section 4, both graphically and econometrically. Details of several robustness checks are given in Section 5, including the addition of a large range of control variables, instrumentation for key variables and the use of alternative corruption measures. Finally, Section 6 concludes.

2 Theoretical model

In order to provide a framework for the empirical analysis, it is useful to construct a simple model that outlines a potential mechanism through which corruption may interact with regulatory autonomy and ownership in its impact on efficiency. To model the role of corruption in infrastructure regulation, I use a static game involving three main actors: a regulated firm, the regulator, and the regulator's principal.

[1] Other studies include Guasch and Straub (2009), who look at the effect of corruption on renegotiation, and Estache, Goicoechea and Trujillo (2009), who consider the impact of corruption on country-level measures of access, affordability and quality. Clarke and Xu (2004) take a different approach by considering the effect of reforms on petty bribery to utility firms.

[2] See, for example, Gutiérrez (2003a); Montoya and Trillas (2007); Cubbin and Stern (2006); Zhang et al. (2008)

[3] For surveys of the empirical literature on privatisation in developing countries, see Parker and Kirkpatrick (2005); Megginson and Sutter (2006); Boubakri et al. (2008)

The model assumes that the firm is required to produce an output of Q. This represents the obligation to provide electricity as demanded to a given set of consumers, which is the mandate of the firms in the sample (Dal Bó and Rossi, 2007). I then focus on the amount of labour that the firm employs to produce this output, which is labeled L. This reflects the fact that capital inputs are closely related to the number of connections and the geographical area of distribution, and are therefore treated in the literature on electricity distribution as exogenous in the short run (see Neuberg (1977); Kumbhakar and Hjalmarsson (1998) and Dal Bó and Rossi (2007)). I therefore consider efficiency as labour efficiency in both the model and the latter empirical analysis, since this is the variable that is most likely to be under firms' direct control. Let us assume that in order to produce the output Q the firm must employ at least $L(Q)$ people. Assuming an exogenous wage rate w, the firm's total cost is then $wL(Q)$.

The statutory role of the regulator in this model is to minimise the firms' revenue, with the constraint that it must allow sufficient revenue to cover total costs. I assume that the firm's total costs $wL(Q)$ are known to the regulator. However, I assume that the regulator can set revenue up to $(1+\gamma)wL(Q)$, with $\gamma > 0$ representing the error which exterior sanctioning agents may make when estimating the firm's costs. These exterior agents may include the judiciary or the electorate, who are unaware of the firm's exact costs due to being less familiar with the firm's operation than the regulator.

Finally, the third actor in the model is the regulator's principal. This may either be a bureaucrat in the ministry to which the regulator is responsible or a politician in control of this ministry. In the model, it is assumed that the principal is also completely informed as to the firm's total cost.[4] However, the principal's control over the regualtor is limited. If it wishes to overrule the regulator's decision on allowed revenue, it can only do so with probability $1-\alpha$, where α is a measure of regulatory autonomy.

The firm's payoff structure is such that it wishes to maximise its revenue. The revenue will then be spent according to bargaining within the firm. A proportion $0 < \pi < 1$ of the excess revenue that the firm receives is taken as 'profits', either for the owners of the firm (if the firm is private) or greater income for employees. The remaining proportion $1-\pi$ is spent on employing a greater number of workers than necessary. This represents the part of the pie that is given to employees whose wages are relatively inflexible or who would otherwise be unemployed.

The payoff of the regulator is such that, if it does not receive a bribe, it will carry out its mandate and try to set revenue equal to cost. However, with probability $\phi_R(c)$, the regulator is dishonest, and is prepared to take a bribe in exchange for trying to set the firm's revenue at its maximum. Here c is a measure of the overall level of corruption in the country. The principal's payoff function is the same, with a probability of being dishonest of $\phi_P(c)$. I assume that the probability of each actor being dishonest is increasing in the national corruption level in the country, i.e. $\phi'_R(c), \phi'_P(c) > 0$.

As far as the firm is concerned, corrupting only the regulator's principal will be useless if the principal fails to exert control over an uncorrupted regulator. Equally, corrupting only the regulator will be useless if the principal is not corrupted and does exert control. I assume that it is always in the firm's interest to attempt to bribe. The overall probability of the firm succeeding in being allowed excess revenue is therefore $(1-\alpha)\phi_P(c) + \alpha\phi_R(c)$.

On average, the total amount of labour employed is then,

$$L = L(Q)\left[1 + (1-\pi)\left[(1-\alpha)\phi_P(c) + \alpha\phi_R(c)\right]\gamma\right] \quad (1)$$

Taking logs and then approximating gives the following equation:

$$ln(L) \approx ln(L(Q)) + (1-\pi)\left[(1-\alpha)\phi_P(c) + \alpha\phi_R(c)\right]\gamma \quad (2)$$

The effect of a change in corruption levels on the log of labour employed can therefore be gathered by

[4] For simplicity, I therefore abstract from problems of asymmetric information between the three main actors. Estache and Wren-Lewis (2009) provide a review of how models of asymmetric information can be used in analyzing problems typical to regulation in developing countries, including corruption.

differentiating this equation,

$$\frac{dln(L)}{dc} = (1-\pi)\left[(1-\alpha)\phi'_P(c) + \alpha\phi'_R(c)\right]\gamma \quad (3)$$

The two reforms that we are concerned with can then be modelled as follows. Privatisation typically involves transferring firm ownership from the state to an organization that is focused on maximising profits. In the context of the model, privatisation can therefore be viewed as an increase in π, since privatisation is likely to both increase the flexibility of employee wages and create an extra outlet for the firm's excess revenue - owners' profits.[5]

Independent regulatory agencies are independent in the sense that they are not part of a government ministry or subject to direct executive control, and therefore they are viewed to be less sensitive to the wills of political elites (Andres et al., 2008). Their role is to implement regulatory policy, which may include setting tariffs, publishing information on firms' performance and enforcing agreed standards of quality and supply. I therefore model the creation of an IRA as an increase in regulatory autonomy, α.

Modelling the two reforms in this way then leads to the following proposition:

Proposition 1. *For a given output Q, labour employed by the firm is increasing in the national level of corruption. Moreover:*

1. *This effect is greater if the firm is public rather than private.*
2. *The impact of creating an IRA on this effect depends on the relative corruptibility of the regulator and its principal. If $\phi'_R(c) > \phi'_P(c)$, then creating an IRA increases the effect, whilst if $\phi'_R(c) < \phi'_P(c)$, then creating an IRA decreases the effect.*

A rise in the national corruption level increases the probability that the firm will be able to bribe either the regulator or its principal. This then increases employment since part of the gains that the firm makes from this corruption will be shared with labour through excess employment. Privatisation reduces the effect of corruption since less of these corrupt gains are distributed to workers through excess employment. Note, however, that privatisation does not reduce the amount the firm receives as a result of corrupt behaviour.

Finally, Proposition 1 tells us that the impact of an IRA's creation on the effect of corruption is ambiguous. If $\phi'_R(c) > \phi'_P(c)$, then the level of national corruption affects the corruptibility of the regulator more than that of its principal. Transferring power towards the regulator then makes the system more sensitive to national corruption levels. On the other hand, if $\phi'_R(c) < \phi'_P(c)$, then it is the principal that is most influenced by the corrupt environment. In this case, transferring power to the regulator reduces their influence, and hence diminishes the effect of corruption on efficiency.

3 Data and empirical strategy

3.1 Data

The empirical analysis is based on the electricity distribution sector in countries in Latin America and the Caribbean over the period 1995 to 2007. The electricity distribution sector has many of the properties typical of network infrastructure, including close government regulation and limited direct competition. Moreover, the period and region is one that includes a number of important reforms as well as substantial variation in the level of corruption both within and between countries.

Whilst all countries in the sample have created an IRA over the period, the governance of these IRAs varies across countries and sectors. Data on regulatory governance is from Andres, Guasch, Diop and

[5] This is therefore similar to the effects of privatisation in Shleifer and Vishny (1994), where privatisation decreases the relative influence of those pushing for excess labour compared to profit-motivated managers.

Azumendi (2007), and includes information on national electricity regulators in over twenty countries as well as for provincial regulators for certain states in Brazil and provinces in Argentina respectively. The data is compiled from a survey containing over fifty different questions to produce indices of various aspects of regulatory governance, including accountability, autonomy and transparency. These include questions such as whether the regulator is financed directly by the government, whether minutes are available publicly and the way in which the head of the agency is appointed. I make use primarily of the Electricity Regulatory Governance Index (ERGI) constructed by Andres, Guasch, Diop and Azumendi (2007), where a rating of 0 represents the worst possible measure of governance and 1 the best. For Argentina and Brazil, I use data on the provincial and state regulatory agencies, since regulation of electricity distribution firms is carried out at this level. From henceforth, I use the term 'province' to mean the area for which the regulatory agency is responsible - either national or state/province as appropriate. Panel C of Table 1 gives summary statistics of the regulatory governance index (ERGI) and when agencies have been created in each country/province. The data is cross-sectional but, since it includes the year in which each regulatory agency was created, I transform it into a panel by giving zero values for all variables in each year before the agency's creation.[6]

Data on firm performance is from the World Bank Latin American and Caribbean Electricity Distribution Benchmarking Database. It contains data on 249 utilities across 25 countries between the years 1995-2007, and overall the firms represent 88 percent of all electricity connections in the region. For the main analysis I use data on the total number of employees, the total number of connections, total electricity sold (in GWh) and whether the firm is privately managed. Summary statistics of firms' characteristics are given in Panel A of Table 1.

Data on corruption is from the International Country Risk Guide, which contains annual country-level data. I use this dataset since it is specifically designed to allow for comparisons between years and countries and contains observations for the entire period for which I have data on firms' performance. The ICRG corruption index is designed to capture the likelihood that government officials will demand special payments, and the extent to which illegal payments are expected throughout government tiers as ranked by panels of international experts. The ICRG index ranges globally between 6 (highly clean) and 0 (highly corrupt). In order to make the results more evident to read, I reverse the ordering of the data such that greater values represent higher levels of corruption and transform the data such that the mean level of corruption in the total sample is 0. A positive value therefore represents an environment where corruption is above the sample average whilst a negative value represents a level of corruption that is below the sample average. Panel B of Table 1 gives summary statistics of the variable by country.

In total, these three data sources combine to create a database of 153 firms across 18 countries with a total of 1359 observations (i.e. this is the largest possible intersection of the three datasets). Panel C of Table 1 shows the number of firms of each type in each country. Of the 153 firms, 53 change ownership over the period (all but three from public to private) whilst 66 begin in the sample without a regulator and then become regulated.

3.2 Econometric Methodology

Kumbhakar and Hjalmarsson (1998) note that while productivity in electricity generation is mainly determined by technology, productivity in distribution is, to a large extent, driven by management and efficient labour use. Moreover, since electricity distribution is highly regulated, decisions on technology and capital are likely to be outside of the firm's control, whilst the firm typically has control over labour. I therefore focus on labour efficiency. Electricity distribution firms in the sample have the obligation

[6] I am therefore implicitly assuming that regulatory governance remains constant during the reign of the agency and that it is unrelated to the quality of regulation prior to the creation of the agency. This is obviously a strong assumption, but if it has any effect on my results it is likely to bias them towards insignificance and therefore should not be of too great a concern when interpreting my results.

Table 1: **Summary statistics**

Panel A: Firm characteristics	Mean	Std. Dev.	Minimum	Maximum
Employees	1,337	3,479	12	40,970
Connections	668,958	1,771,628	2,499	23,265,575
Electricity (GWh)	3,619	11,201	3	140,283
Interruption frequency (No. per year)	35.38	61.21	0.00	533.50
Interruption duration (hrs per year)	33.43	61.02	0.01	704.65
% of electricity lost	16.41	9.63	2.10	71.88
Avg. residential tariff ($)	83.71	29.52	11.41	176.60
Avg. industriall tariff ($)	75.32	24.90	9.22	147.20
Panel B: Corruption index				
Argentina	0.22	0.41	-0.29	0.71
Bolivia	0.14	0.51	-0.29	0.71
Brazil	0.01	0.61	-1.29	0.88
Chile	-0.97	0.64	-1.79	0.21
Colombia	0.30	0.55	-0.29	1.21
Costa Rica	-0.99	1.42	-2.29	1.21
Dominican Republic	0.19	0.90	-1.29	0.71
Ecuador	-0.23	0.43	-0.70	1.09
El Salvador	-0.51	0.67	-1.29	0.21
Guatemala	-1.23	0.10	-1.29	-1.12
Haiti	1.38	0.35	0.80	1.71
Honduras	0.61	0.21	0.21	0.80
Jamaica	1.21	0.00	1.21	1.21
Mexico	0.32	0.51	-0.70	0.71
Nicaragua	-0.25	0.68	-1.29	0.21
Panama	0.71	0.00	0.71	0.71
Peru	-0.07	0.43	-0.95	0.71
Uruguay	-0.29	0.00	-0.29	-0.29
Full sample	0.00	0.82	-2.29	1.71

Panel C: Regulators and firms	IRA		No. of Firms, by ownership		
	Start year	ERGI	Private	Public	Changed
Argentina	1996[a]	0.64[a]	2	2	3
Bolivia	1996	0.84	1	0	6
Brazil	2000[a]	0.71[a]	10	4	21
Chile	1990	0.56	23	0	0
Colombia	1994	0.76	0	16	4
Costa Rica	1996	0.74	0	8	0
Dominican Republic	1998	0.75	0	0	2
Ecuador	1999	0.61	0	19	1
El Salvador	1997	0.82	1	0	4
Guatemala	1996	0.79	1	0	0
Haiti	1983	0.37	0	1	0
Honduras	1995	0.56	0	1	0
Jamaica	1997	0.72	1	0	0
Mexico	1995	0.72	0	2	0
Nicaragua	1985	0.75	0	0	2
Panama	1996	0.63	0	0	3
Peru	1996	0.84	2	7	7
Uruguay	2000	0.73	1	0	0
Overall median/total	1997	0.72	41	61	53

Source: World Bank; International Country Risk Guide

Note: Firm characteristics are averaged across all observations in the sample.

[a] For Argentina/Brazil, regulatory statistics given are the median of the province/state regulators.

to meet demand, and I can therefore consider the amount of electricity sold to final customers and the number of final customers served as exogenous outputs.

I therefore follow Dal Bó and Rossi (2007) in estimating a parametric labour requirement function. In particular, I use a translog functional form because it provides a good second-order approximation to a broad class of functions. Included in this function is the number of electricity connections the firm serves and the amount of electricity it sells. This equation for a panel of $i = 1, , N$ firms producing in $c = 1, , C$ countries and observed over $t = 1, , T$ periods may therefore be specified as

$$\begin{aligned} l^{i,t} &= \alpha_i + \psi_t + \sum_{m=1}^{2} \omega_m y_m^{i,t} + \frac{1}{2} \sum_{m=1}^{2} \sum_{n=1}^{2} \omega_{mn} y_m^{i,t} y_n^{i,t} \\ &\quad + \beta_1 Cor^{c,t} + \beta_2 Cor^{c,t} * Pri^{i,t} + \beta_3 Cor^{c,t} * IRA^{i,t} + \beta_4 Pri^{i,t} + \beta_5 IRA^{i,t} + \nu^{i,t} \end{aligned} \tag{4}$$

where l, y_1 and y_2 are the natural logarithms of labour, sales and customers, Cor is the level of national corruption, Pri is a dummy variable for private ownership, IRA is a dummy variable indicating if the firm is regulated by an IRA and ν is the random error term. To account for time effects in a flexible way I include year fixed effects ψ_t. The year fixed effects measure the efficiency impact of sector-level shifts over time, such as secular technology trends, international macroeconomic fluctuations or energy price shocks.

I use firm fixed effects to control for any time-invariant unobservables, represented as α_i in the equation above.[7] I also cluster standard errors on country-year combinations, in order to address the concern that the shocks affecting firms in a given country in the same year may be correlated.

Overall, the estimated equation therefore resembles Equation (2) which derives from the theoretical model. Proposition 1 therefore predicts that $\beta_1 > 0$ and $\beta_2 < 0$, with $|\beta_1| > |\beta_2|$ and $\beta_3 > -\beta_1$. Whilst the model also suggests that there should be an interaction between ownership and regulation, I unfortunately cannot analyse this empirically due to the fact there are very few observations of unregulated private firms in the sample.

4 Empirical Results

4.1 Graphical Analysis

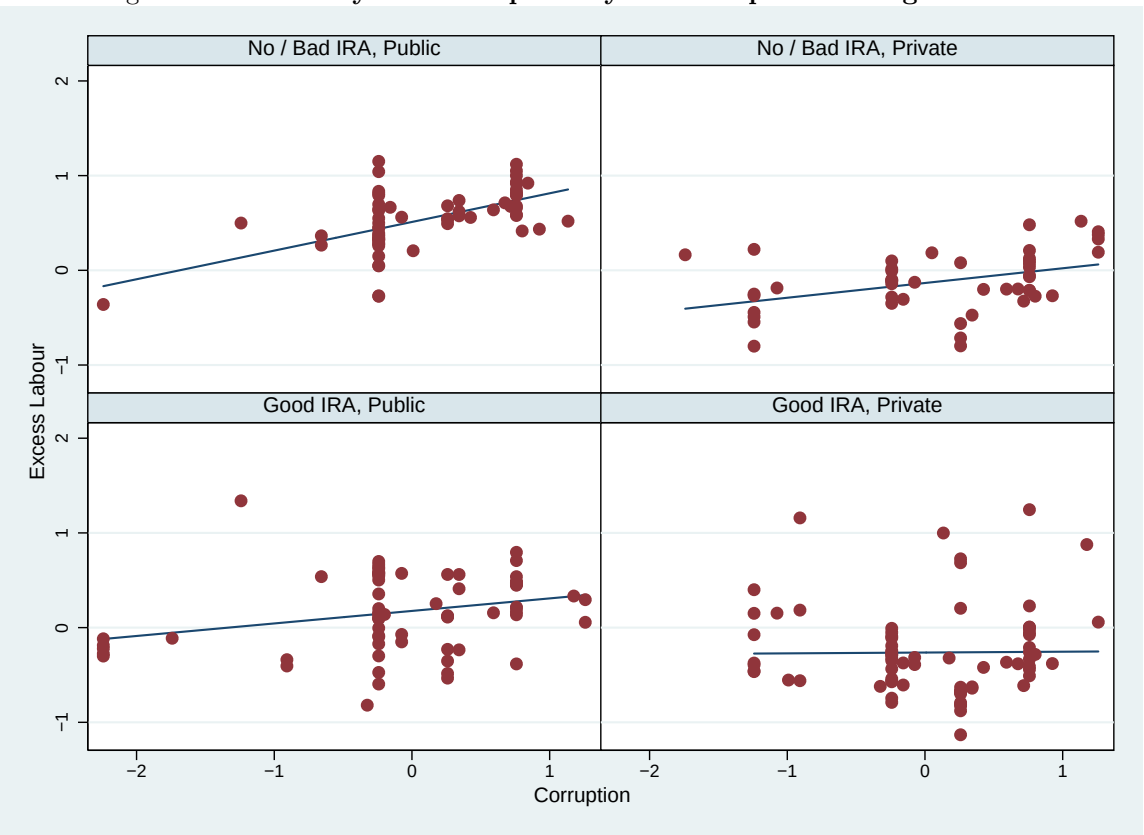
Before beginning with the econometric analysis, let us display the data graphically to consider the link between inefficiency, corruption and regulatory governance. For this subsection, inefficiency is measured by regressing the log of employees on the translog function described in Equation (4) and storing the residuals.[8] This thus creates a measure of 'excess labour', which gives us an idea of how efficient the firm is in any year are compared to the average of all firms over the whole period.

Figure 1 plots excess labour against corruption separately for firms in four different environments. The upper two panels consider observations of firms operating under either no IRA or a 'bad' IRA (i.e. below-median ERGI score), whilst the lower two panels consider observations of firms operating under 'good' IRAs (i.e. an above-median ERGI score). These pairs are then each divided into publicly operated firms on the left panel and privately operated firms on the right.

[7] In addition to electricity produced and connections, Dal Bó and Rossi (2007) also include the service area as an exogenous output and transformer capacity and the length of the distribution lines as exogenous capital variables. Unfortunately the first two of these variables are not available in the extended dataset that I use, and including the latter reduces my sample by over a half. However, since these variables vary little over time, they are likely to be controlled for using firm fixed effects. Indeed, I test for this by carrying out the regressions with the length of distribution lines included in the translog function and find the variable to be insignificant with no significant changes in my results. Moreover, using the dataset from Dal Bó and Rossi (2007), I find that their results are not sensitive to the removal of the service area and transformer capacity from the labour demand function.

[8] We do not include firm or year fixed effects

Figure 1: **Inefficiency and corruption by ownership and IRA governance**



Note: Excess labour is the residual when labour is regressed on the translog function of firm outputs. An IRA is categorized as 'bad' or 'good' depending on whether its ERGI score is above or below median. The points plotted are averages across firms for a given country-year after observations have been divided according to their ownership and regulation.

From Figure 1 , we can see that both reforms appear to affect the relationship between corruption and inefficiency. The upper left panel, where firms are publicly owned and not regulated by an above average IRA, shows the clearest positive relationship between corruption and inefficiency. The upper right panel and the lower left panel then show that, for firms that are either privately operated or regulated by an IRA with above median governance, the relationship between corruption and inefficiency is weaker. Moreover, there appears to be no clear relationship between corruption and inefficiency when both of these reforms has been undertaken, as shown in the lower right panel. I now investigate these results more formally using an econometric analysis.

4.2 Econometric analysis

The results of the econometric analysis outlined in Section 3.2 are presented in Table 2. To save space, the coefficients on the translog function and year dummies are not reported. It is worth noting however that coefficients on the terms in the translog function are reasonable, suggesting that firms have increasing

returns to scale.[9] I also note that the coefficients on the translog function are very similar if the sample is split into private and public firms, supporting the assumption that the translog function is relatively unaffected by ownership.

Table 2: **Baseline Regression**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Corruption	0.21***	0.21***	0.21***	0.21***	*0.34****	0.17**	0.20***
	(0.033)	(0.030)	(0.028)	(0.028)	*(.017)*	(0.072)	(0.026)
Corruption × private	-0.092***	-0.089***	-0.084***	-0.084***	-0.26***	-0.076***	-0.054**
	(0.025)	(0.025)	(0.024)	(0.023)	(0.057)	(0.022)	(0.021)
Corruption × IRA	-0.14***	-0.12		-0.14***	-0.14***	-0.099	-0.15***
	(0.032)	(0.096)		(0.027)	(0.027)	(0.074)	(0.023)
Private dummy	-0.29***	-0.27***	-0.26***	-0.26***	-0.27***	-0.26***	*-0.25****
	(0.036)	(0.036)	(0.035)	(0.035)	(0.036)	(0.041)	*(0.026)*
IRA dummy	-0.021	0.49**				*-0.022*	
	(0.037)	(0.22)				*(0.23)*	
ERGI		-0.72**					
		(0.31)					
Corruption × ERGI		-0.024					
		(0.12)					
Bad IRA dummy			0.12***	0.12***	0.12***		0.14***
			(0.037)	(0.036)	(0.041)		(0.038)
Good IRA dummy			-0.11***	-0.11***	-0.13***	-0.19***	-0.14***
			(0.038)	(0.038)	(0.040)	(0.037)	(0.031)
Corruption × bad IRA			-0.14***				
			(0.037)				
Corruption × good IRA			-0.14***				
			(0.027)				
Corruption * firm dummies					Yes		
IRA * country dummies						Yes	
Private * country dummies							Yes
Observations	1359	1359	1359	1359	1359	1359	1359
Number of firms	153	153	153	153	153	153	153
Adjusted R^2	0.35	0.36	0.37	0.37	0.45	0.39	0.41

Note: Dependent variable is ln(labour employed).In all cases we are estimating a translog labor requirement function with year dummies and firm fixed effects. To save space technological parameters of the translog function are not shown. Country-year clustered standard errors in parentheses. Coefficients shown in italics are the mean effects across firms/countries, with standard errors calculated accordingly.
*** Significant at the 1% level , ** Significant at the 5% level, * Significant at the 10% level

Column (1) of Table 2 explores the assocation between corruption and efficiency. We can see that the coefficient on the corruption term is positive and strongly significant, which suggests that higher corruption levels go along with a greater number of workers to be employed for a given function of outputs. However, we also see that corruption interacts significantly with both the private ownership dummy and the dummy indicating the presence of an IRA. In both cases the coefficient is negative and of a smaller magnitude than the coefficient of corruption. This suggests that the negative relationship between corruption and efficiency is significantly reduced if the firm is either privately owned or regulated by an IRA.

These results are therefore consistent with Proposition 1 in the theoretical model above. Furthermore, the proposition suggests that we should interpret the negative coefficient on the Corruption × IRA term

[9]The coefficients suggest that if both output measures were to double then the increase in labour required would be 59%. This is very close to the value I obtain by using the data from Dal Bó and Rossi (2007), which suggest a doubling of outputs requires a 62 % increase in employees.

to mean that the regulator is less affected by national corruption levels than its principal. In other words, the model suggests that regulatory independence reduces the effect of corruption because it moves power away from the relatively more corruptible principal.[10]

We may also note that the coefficient on the IRA dummy in column (1) is insignificant. Given that corruption is scaled such that its mean sample value is zero, this suggests that the creation of a regulatory agency does not affect efficiency if corruption is at the average sample level. On the other hand, the significant coefficient on the private dummy suggests private firms are more efficient than public ones at average corruption levels.

In column (2) I introduce a measure of regulatory governance, ERGI, both linearly and interacted with corruption. We observe that the linear term is significant and negative, suggesting that better regulatory governance is associated with more efficient firms. However, the coefficent on the Corruption $\times$ ERGI term is insignificant and very close to zero, suggesting that this measure of regulatory governance is not particularly effective at reducing the effect of corruption. In this regression, the Corruption $\times$ IRA term also becomes insignificant due to its close correlation with the Corruption $\times$ ERGI term. However, the two terms together are significantly different from zero.[11]

Column (3) considers regulatory governance in a different way, by creating a binary measure of goverance rather than using a continuous variable. The 'Bad IRA' dummy here indicates the presence of an IRA which is in the bottom 30 % of regulators scored on ERGI, whilst the 'Good IRA' dummy represents the presence of an IRA which has an ERGI placing it in the top 70 % of regulators.[12] It is interesting to note that the coefficient on the 'Bad IRA' dummy is significantly positive whilst that on the 'Good IRA' dummy is significantly negative, again suggesting that governance is important when considering the link between efficiency and IRA creation. On the other hand, the coefficients on the two terms interacted with corruption are almost identical, suggesting that both types of regulator are equally good at mitigating the effect of corruption. In column (4) I therefore run the regression using a simpler specification where these two coefficients are imposed to be equal. This column forms the baseline regression for the future robustness checks

In order to explore the results further, columns (5)-(7) include a range of dummy variables which I interact with variables of interest. In column (5), I allow for firms to react differently to corruption by interacting corruption with time-invariant firm dummies. In this column, the coefficient reported in the space of the corruption term (shown in italics) is calculated as the average effect of corruption across firms.[13] The fact that there is no reduction in the size or significance of the Corruption $\times$ private or Corruption $\times$ IRA coefficients shows that these results are at least in part being driven by firms who change ownership or regulation over the period.

In column (6) I allow for the effect of IRA creation to vary across countries. The Corruption $\times$ IRA term becomes insignificant here, which suggests that a significant part of this result is driven by differences in corruption between countries. In other words, the time variation in corruption is not sufficient to give significance to this coefficient, although the coefficient does not change significantly. Given that corruption is only measured at the country level, and differences in measured corruption between countries are generally greater than those over time within countries, this is not surprising.

[10] The model also suggests there may be an interaction between corruption, ownership and regulatory autonomy. However, if I introduce such an extra term I find it to be insignificant. This is likely to be due to the relative lack of firms in the sample that are privately owned and not regulated by an IRA.

[11] I have explored breaking down the ERGI into different governance components, but no particular component is more successful in explaining firm performance than the ERGI measure across all firms. Similarly, no governance component consistently improves upon the IRA dummy when interacting with corruption. This is explored in more detail in (Wren-Lewis, 2010, pp. 207-213).

[12] The 30/70 split was chosen as it maximises the difference between the coefficients on the two linear terms. The difference between the two coefficients however remains strongly significant for a range of other ways of splittling the sample of regulators by ERGI.

[13] The coefficient is therefore the mean of the coefficients of the corruption terms interacted with the firm dummies, whilst the standard error is calculated by taking the square root of the sum of the estimated variances divided by the number of firms.

Finally, in column (7), I allow for the effect of privatisation to vary across countries, with the coefficient shown in italics here representing the average effect of privatisation across countries. Whilst the coefficient on the Corruption × private term falls, it is still statistically significant at the 5% level. This suggests that the privatisation result is only partially being driven by differences in the effect of privatisation across countries, with a significant portion stemming from a difference in the reaction of firms to temporal changes in corruption levels.

Let us consider the size of the various effects by studying the coefficients on the variables in column (4). Focusing on the coefficient on corruption, the value of .21 suggests that an increase in measured corruption of one standard deviation (.82) is associated with a 19% increase in the amount of labour employed for a given amount of outputs. However, this assumes that the firm is publicly owned and not subject to regulation by an IRA. If the firm was private, then this association is reduced by about 40%. Alternatively, if the firm was public but subject to regulation by an IRA, then the association is reduced by about two thirds. The average effect across all firms is therefore slightly smaller than that found by Dal Bó and Rossi (2007), which is consistent with the fact that the later sample contains a greater proportion of private firms and firms regulated by an IRA. The importance of governance is also substantial - firms regulated by a 'Good IRA' rather than a 'Bad IRA' have 25 % fewer employeees.

Of course, these empirical estimates should be taken with caution, since the point values are not precisely estimated and in reality the interaction effects are likely to be much more complex.[14] Nonetheless, they do suggest that the factors considered in the analysis each have a very strong economic importance, and that the impact of institutional reforms can be large.

Overall therefore, three main conclusions arise from this econometric analysis. First, corruption appears to be significantly negatively associated with labour efficiency. Second, this association is reduced if the firm is either privately owned or there exists an Independent Regulatory Agency. Third, firms operating under an IRA with a higher level of regulatory governance operate more efficiently. In the next section, I aim to consider whether these results are robust to changes in the assumptions or methodology.

5 Robustness Checks

5.1 Extra Control Variables

One concern with the results above may be that the variables included are correlated with other omitted variables that affect firm efficiency. In order to check for this problem, one can introduce other variables into the equation and observe whether the coefficients on the original variables are affected.

Since the baseline regression includes ownership and IRA dummies linearly and interacted with corruption, to test for omitted variable bias in these coefficients we include a range of control variables along with a term interacting the control variable with corruption. These control variables include a number of aspects of the regulatory environment, including the power of the incentive scheme and whether the electricity sector has been vertically disintegrated.[15] I then consider a number of country-level variables such as GDP per capita, national wage levels and urbanisation. A selection of these variables and their sources are given in Appendix A. Running the baseline regression (column (4) in Table 2) I find that many of these additional variables and their interactions are significant when introduced. However, the Corruption × IRA and Corruption × private terms always remain significant, and we can therefore conclude that these interaction terms are not proxying for any other country level variable. Moreover,

[14] Moreover, as pointed out by Mauro (1995), it is not clear that perception indices such as that of corruption truly form a cardinal measure. If instead we interpret the index as ordinal, it is clear that we would not expect the same effects from a jump in corruption from -0.1 to 0 as an increase from 0.7 to 0.8, for example.

[15] For more details, see Wren-Lewis (2010, pp. 213-216). One notable result is that the power of the incentive scheme explains a significant portion of the difference between 'good' and 'bad' IRAs, which is consistent with Estache and Rossi (2005). However, there is no significant interaction between corruption and the power of incentives.

the difference between the 'Bad IRA' dummy and the 'Good IRA' dummy always remains significant, and hence I conclude that regulatory governance is not proxying for an alternative country-level variable.

To test whether corruption is proxying for an alternative variable, I next include each control variable and its interaction with both private ownership and the IRA dummy. Again, many of the variables and their interactions are significant. It is also the case that on occasion one of the three corruption terms (i.e. either Corruption, Corruption × IRA or Corruption × private) becomes insignificant, particularly when the sample size is substantially reduced. However, of most concern to us is whether one or more of the of the corruption terms become insignificant and substantially smaller in magnitude whilst the relevant control term is significant. For example, if Corruption × IRA were to become insignificant but retain a similar coefficient when GDP per capita and its interaction terms were introduced, we would only be really concerned if the GDP per capita × IRA term was significant. For all of the control variables, this is not the case. On the few occasions where one of the corruption terms becomes insignificant, the corresponding term involving the control variable is also insignificant. Overall therefore, I can conclude that the results are unlikely to be being driven by omitted variable bias.

5.2 Instrumental Variables

One way to control for potential endogeneity of the key explanatory variables is to use an instrumental variable approach. Although I believe that problems of reverse causality are not likely to affect the corruption or regulatory governance terms, for reasons discussed below, such possibilities cannot be ruled out. In this section I therefore instrument separately for corruption, regulatory governance and ownership using a variety of instruments. Whilst the instruments are imperfect, they may provide us with some reassurance that the results are not being driven by reverse causality.

In terms of corruption, Dal Bó and Rossi (2007) find no evidence that corruption is endogenous when explaining firm performance. Indeed, reverse causality seems unlikely since sector specific shocks will generally not affect corruption in the entire country, whist shocks that affect the whole economy are likely to be captured by the use of control variables such as GDP per capita. However, since I cannot rule out the possibility of endogeneity, I check for robustness by instrumenting the measure of corruption.

The set of instruments that I use for corruption include a measure of press freedom, years left of current leader's term and whether they can run again, and average years of education.[16] Each of these variables should not have any direct effect on firm performance, and indeed when entered into the regression along with the appropriate interaction terms (e.g. Term remaining × IRA dummy, Term remaining × private) I find that they are all insignificant.

Regulatory governance is perhaps more prone to problems of reverse causality since it may be that a firm's performance influences decisions about regulatory governance. However, I do not believe that this is likely to be responsible for the positive effect of regulatory governance on efficiency. This is because such a reverse influence is likely to depend on performance over the longer-term and will hence be captured by firm fixed effects. Nonetheless, I check for robustness by instrumenting for regulatory governance since I cannot completely rule out endogeneity. I use measures of regulatory governance in two other sectors, telecoms and water, since I believe the governance of these sectors is likely to be related to that of the electricity sector.[17] Moreover, firm performance in the electricity sector is unlikely to influence regulatory governance in other sectors in the short term.

[16] These variables are taken from Freedom House, Beck et al. (2001) and Barro and Lee (2001) respectively. Chowdhury (2004) finds that greater press freedom is significantly negatively correlated with corruption, whilst Persson et al. (2003) and Fréchette (2006) show that average years of education is also significantly correlated. Ferraz and Finan (2011) show that corruption increases significantly when politicians are not subjected to electoral pressure.

[17] For the telecoms sector, I use an index of regulatory governance constructed by Gutiérrez (2003b). For water, I use a simple dummy which indicates whether an IRA exists regulating the water sector, as well as the number of years ago that the regulator was created, which I take from Estache and Goicoechea (2005). Each of these two variables, and their interactions with corruption, are insignificant when included as controls in the baseline regression, supporting the belief that they are exogenous.

Ownership is perhaps the variable most likely to suffer from problems of reverse causality. It may well be that the firms with the most potential for improvement are those which are privatised, which would produce a negative coefficient on the Private term. Moreover, it may be that this is felt particularly in corrupt environments if, for example, corrupt governments are most interested in taking a cut from large sales revenues. This, in turn, would produce a negative coefficient on the Corruption $\times$ private term, as was found above. It is therefore particularly important to attempt to instrument for ownership. However, finding valid and informative instruments for private ownership is the most difficult, since this is a firm-level variable, and other available firm-level variables are themselves likely to affect efficiency directly or be affected by efficiency. I therefore have to use instruments that are measured at the province or country level. At the province level, I use the number of years since Private Participation in Infrastructure (PPI) has existed in the country/province, excluding the energy sector.[18] This gives us an indication of a province or country's tendency to privatise network infrastructure generally, which should not be affected particularly by the performance of the electricity distribution sector. As a second variable, I use a measure of economic globalisation constructed by Dreher (2006a). This is likely to be positively correlated with privatisation since countries that are more open to international finance will find privatisation more profitable. Again, both variables and their interaction terms are insignificant when entered as controls into the regression.

The results of the two-stage least squares regressions are presented in Table 3, where the variables included are the same as in column (4) of Table 2. In column (1), I instrument for the three corruption terms, in column (2) for the two regulator dummies and the Corruption $\times$ IRA term and in column (3) for private ownership and the Corruption $\times$ private term. In each case, the instruments are interacted with the appropriate variable(s) and these new variables are also included as instruments. The coefficients of terms instrumented for are displayed in bold.

From Table 3 we can see that the coefficients generally keep the same sign as in the baseline equation, with most of them remaining significant. The exception is the Corruption $\times$ private term, which is insignificant in columns (1) and (3), when corruption and ownership are being instrumented for respectively. Though this may well stem from problems with the instruments, it perhaps suggests that we should be less confident of the corruption mitigating effect of privatisation when compared to the creation of an IRA.

In the lower rows of Table 3 are the results of various tests regarding the validity of the assumptions used. In order to test whether the instruments are sufficiently strong, the Kleibergen-Paap Wald rank F statistic is calculated. The cutoff values calculated by Stock and Yogo (2002) suggest that the instruments are fairly strong, with a bias relative to OLS of less than 20%, 10% and 5% in the three regressions respectively. Also reported are the p-values of the Sargan-Hansen test of instrument validity. The joint null hypothesis under this test is that the instruments are valid, i.e. uncorrelated with the error term. The p-value for this test is displayed in the table, and we can see that in none of the three cases do we have grounds to reject the assumption that the instruments are valid.

Finally, I would like to test whether corruption, regulatory governance and ownership can each be treated as exogenous. To do so, the difference of two Sargan-Hansen statistics is calculated, one for the equation where the possibly endogenous variables are instrumented, and one for a specification where these possibly endogenous variables are added to the instrument set.[19] The p-value resulting from the associated test is above 0.1 in all the equations, and hence we cannot reject the null hypothesis that corruption, regulatory governance and ownership can each be treated as exogenous. Alternatively, one can test for the endogeniety of the variables by running Hausman tests comparing the baseline regression with each of the IV regressions. In each case, there is no strong evidence to reject the null hypothesis of non-systematic differences in the coefficients. I therefore conclude that it is reasonable to treat all of these variables as exogenous as we did in the main analysis.

[18] This is constructed from the World Bank's PPI Project Database, with the six potential sectors being water, telecoms, roads, airlines, sea ports and railways.

[19] For more details of this test, see Hayashi (2000, pp. 233-34).

Table 3: **Robustness checks**

	Instrumented variable:			Corruption measure:		
	Corruption	IRA	Private	0/1	WBES	Brazil
	(1)	(2)	(3)	(4)	(5)	(6)
Corruption	**0.32*** **	0.23***	0.14**	0.20***	0.14***	
	(0.11)	(0.076)	(0.062)	(0.059)	(0.049)	
Corruption × private	**-0.054**	-0.073***	**0.0039**	-0.13***	-0.021	0.067
	(0.052)	(0.020)	**(0.077)**	(0.032)	(0.045)	(0.36)
Corruption × IRA	**-0.22***	**-0.17****	-0.12***	-0.10*	-0.16***	-0.85**
	(0.12)	**(0.077)**	(0.046)	(0.059)	(0.033)	(0.28)
Private dummy	-0.26***	-0.25***	**-0.41*****	-0.23***	-0.29***	-0.31
	(0.027)	(0.044)	**(0.12)**	(0.038)	(0.048)	(0.28)
Bad IRA dummy	0.091*	**0.30*****	0.16***	0.17***	0.22***	0.78**
	(0.051)	**(0.10)**	(0.046)	(0.035)	(0.053)	(0.27)
Good IRA dummy	-0.14***	**-0.14**	-0.043	-0.070**	0.066*	0.64**
	(0.049)	**(0.15)**	(0.060)	(0.035)	(0.033)	(0.23)
Observations	1359	1359	1359	1359	1229	343
Number of firms	153	153	153	153	141	35
R^2	0.26	0.26	0.24	0.38	0.39	0.65
Kleibergen-Paap Wald F stat	7.72	7.92	14.6			
Endogeneity test p-value	0.30	0.16	0.21			
Hansen J exog. test p-value	0.36	0.25	0.41			
Identification test p-value	0	1.7e-09	0			

Notes: See notes to Table 2. Terms in bold in columns (1)-(3) are those treated as endogenous.
*** Significant at the 1% level , ** Significant at the 5% level, * Significant at the 10% level

5.3 Alternative corruption measures

As stated earlier, I have used the corruption index produced by ICRG since this has been designed to be comparable over time within countries as well as between countries. However, we may be concerned that the results are being driven by peculiarities of this index. Table 3 therefore presents the baseline regression carried out using three alternative measures of corruption.

First, the ICRG index is replaced with an indicator variable that takes a value of one if the ICRG corruption index is above the sample median, and a value of zero if it is below. This indicator will not generally be sensitive to extreme values or small annual changes in the index. From column (4), we can see that results do not change significantly, and hence we can be confident that the results are not being driven by extreme values in the corruption index.

I next construct a measure of corruption based on World Bank Enterprise surveys, which ask firms how significant an obstacle corruption is in doing business. The measure therefore differs from the ICRG index both in sourcing from firms rather than experts and in providing an indication of corruption costs rather than corruption frequency. Moreover, since I have access to the firm level data, I can construct a measure of corruption for some states and provinces within Brazil and Argentina, and we therefore do not use country-level indicators for these two countries. However, there are only one or two waves of this survey per country, and I therefore have to fill in missing values.[20] The measure is also scaled to produce comparable coefficients to the measure of corruption used in the main analysis. The regression using this data is presented in column (5). We can see that all coefficients remain similar to when the ICRG index is used. Although the Corruption × private term loses significance, we cannot reject the hypothesis that the ratio β_2/β_1 is as previously found, where these coefficients are as defined in Equation (4).

[20] For provinces/countries where I have at least one observation, I use linear interpolation to fill in missing values between observations, and take the value of the nearest observation otherwise.

Finally, a weakness of the previously used measures is that they are survey based measures rather rather than direct measures of corrupt activities. This may be a problem if corruption perceptions systematically differ from true corruption levels, as suggested by Olken (2009). In column (6) I therefore use a measure of observed corruption constructed from data on federal auditing of Brazilian municipalities used by Ferraz and Finan (2011). The corruption measure is the fraction of audited municipalities in which corruption was detected, varying by state, with municipalities weighted by their population. From column (6), we can see that the Corruption × IRA term is again significant and negative. Since the measure of corruption does not vary over time, the fixed effects model used here cannot estimate the effect of corruption. However, using a random effects model (not reported here) I obtain a coefficient of 1.24, significant at the 5% level, with the Corruption × IRA term remaining negative and significant.

Overall therefore we can see that the previously found negative association betwen corruption and efficiency and the mitigating effect of an IRA are robust to using these three alternative corruption measures.

5.4 Quality and prices

One concern that we may have with the previous analysis is that the dependent variable, 'excess labour', might not have been 'excess', but instead employed to raise the quality of outputs. Moreover, it would also be useful to know whether the results discovered above carried beyond changes in labour employed to changes in consumer prices. Table 4 therefore presents the results of regressing other firm-level variables on corruption, ownership and regulation.[21] Columns (1) and (2) use two measures of quality, namely the frequency and duration of interruptions in the power supply, whilst Column (3) has the percentage of electricity lost through distribution as the dependent variable. In columns (4) and (5) two price measures are given, the tariffs faced (in $) by residential and industrial consumers respectively. These variables were not included in the main analysis since they are not always observed. Summary statistics of all of these variables can be found in Table 1.

The results presented in columns (1)-(3) help to alleviate any concern that previously noted variations in labour employed may reflect variations in quality.[22] The coefficients involving corruption in these regressions are generally insignificant, suggesting that the corruption related results found previously are not being driven by changes in quality or investment levels. Moreover, the reforms of interest generally appear to be significantly postitively associated with quality.

The coefficients in columns (4) and (5) suggest that the previously noted changes in efficiency do correlate with changes in consumer prices. Though generally not highly significant, each coefficient is of the same sign as in the baseline regression. We can therefore interpret this as suggesting that consumers are reaping some of the gains of efficiency improvements noted previously. This also lends weight to the assumption in the model that efficiency are effects are driven by revenue control methods of regulation.

5.5 Other robustness checks

I have carried out various other permutations of the baseline equation, including:

- Dropping each year and country individually from the sample.
- Replacing the variable *MWh sold* with *MWh sold + losses*, to reflect the fact that the amount of electricity lost varies between firms and over time.

[21] Unlike in the prior analysis, I do not regress these dependent variables on a function of firm outputs.

[22] I also enter each quality variable into the baseline regression and find each to be insignificant and not to substantially change the coefficients of interest.

Table 4: **Quality and prices**

Dependent variable:	Interruption Frequency	Interruption Duration	% of elec. Lost	Residential Tariff	Industrial Tariff
	(1)	(2)	(3)	(4)	(5)
Corruption	-5.92	-7.34	0.048	14.5	40.4*
	(8.00)	(11.6)	(1.04)	(12.9)	(22.8)
Corruption × Private	1.68	1.37	1.10**	-1.37	-7.15*
	(4.79)	(7.87)	(0.50)	(3.19)	(3.86)
Corruption × IRA	1.31	1.31	-0.51	-13.2	-35.6
	(4.46)	(6.53)	(0.98)	(12.8)	(23.2)
Private dummy	-11.6*	-16.3*	-1.27*	-6.73***	-2.87
	(6.51)	(9.54)	(0.72)	(2.26)	(4.06)
Bad IRA dummy	-15.0***	-21.1***	6.32***	15.0**	7.92
	(4.13)	(7.11)	(1.04)	(6.42)	(14.9)
Good IRA dummy	-21.8*	-20.6**	-0.035	-18.3***	-11.8
	(11.3)	(9.52)	(1.58)	(4.23)	(8.75)
Observations	776	809	1211	979	571
Number of firms	118	119	147	130	78
Adjusted R^2	0.052	0.032	0.11	0.35	0.22

Note: In all cases we are estimating with year dummies and firm fixed effects. Country-year clustered standard errors are in parentheses.
*** Significant at the 1% level , ** Significant at the 5% level, * Significant at the 10% level

- Including placebo variables indicating whether an IRA will be created or ownership will change in one or two years time.[23]
- Using a Cobb-Douglas function rather than the translog used above, as well as simply using *Connections/Employees* as a dependent variable.
- Using a random effects estimator rather than a fixed effects estimator.
- Including the length of the distribution network in the translog function.
- Including country specific trends and allowing the effect of corruption to vary over time.
- Weighting by firm size and splitting the sample into firms that are small (i.e. below median amount of electricity sold) and firms that are large (i.e. above median amount of electricity sold).

In each of these permutations, the Corruption, Corruption × IRA and Corruption × private terms remain significant with the expected signs. I have also carried out the regression clustering standard errors at the firm level, which allows for the error term to be correlated within these clusters. Since the coefficients of interest remain significant, we can conclude that the results are probably not being driven by mistakenly using a static model rather than a dynamic one.

6 Conclusion

This paper analyses the relationship between corruption and regulated firms' efficiency and the way in which this interacts with policy reforms. The paper sets out a potential channel through which corruption

[23] Wren-Lewis (2010, pp.204-207) considers in more detail how the effect of an IRA changes over its lifetime and shows that the corruption mitigating effect appears to be constant. In terms of privatisation, efficiency does appear to increase prior to the change in ownership (see Chong et al. (2011) for more details on such retrenchment policies), but the interaction with corruption is not significant.

increases labour employed and analyses how privatisation and regulatory autonomy may interact with this mechanism. This provides a framework for an empirical investigation of the effect of corruption on electricity distribution firms in Latin America.

The econometric analysis shows that corruption at the national level is negatively associated with firm efficiency. This result adds to the increasing evidence that corruption can be detrimental to the performance of utilities. I also find that the association between corruption and efficiency is smaller for private firms than public ones. This suggests that privatisation may be a way to reduce the potentially negative effects of corruption. However, the analysis suggests caution when making this prediction, since the significance of this result disappears when I try to control for the possible endogeneity of private ownership.

A more robust finding is that the introduction of an Independent Regulatory Agency substantially reduces the negative association between corruption and efficiency. This result survives controlling for firm specific corruption effects and introducing a large range of control variables. Moreover, the result is robust to instrumenting individually for both corruption and regulatory governance, and still holds when I use alternative corruption measures based on firm surveys and observed corruption. Interpreting this result in the framework of the theoretical model suggests that the regulators' principals (such as national politicians) are more sensitive to national corruption levels than the regulatory agency.

These results further emphasize the need to consider institutional weaknesses when developing the appropriate sectoral policies. In particular, they imply that there may be reason to adapt reform priorities according to the level of national corruption. Identifying precisely which aspects of regulatory governance are important in tackling corruption will require further research, both at the country level and with cross-country data on how regulatory governance varies over time. More broadly, the paper also suggests that the negative effects of macro-level governance failures can be significantly reduced with well-designed micro-level institutions. This provides further hope that there are effective ways to reduce the problems caused by widespread corruption.

Appendix A: Selection of additional country control variables

Control variable	Description	Source
GDP per capita	Constant 2000 US$	World Bank (2009)
Workers compensation	Employees compensation / GDP	World Bank (2009)
Population density	People per square km	World Bank (2009)
Fuel Exports	% of merchandise exports	World Bank (2009)
Urbanisation	Urban population / total	World Bank (2009)
Trade	Imports & Exports / GDP	World Bank (2009)
Shadow Economy	Share of total GDP	Schneider (2007)
Length of office	Yrs ruling party in power	Beck et al. (2001)
Executive orientation	Left-wing/central/right-wing	Beck et al. (2001)
Separation of powers	Does the party of the executive control legislature?	Beck et al. (2001)
Elections	Dummy for election year	Beck et al. (2001)
World Bank presence	Number of WB projects	Boockmann and Dreher (2003)
IMF presence	IMF agreement dummy	Dreher (2006b)
Legislative effectiveness	Index	Norris (2009)
General strikes	Number of strikes	Norris (2009)
Workers Rights	Index	Teorell et al. (2009); Cingranelli and Richards (2009)
Government deficit	% of GDP	Teorell et al. (2009); Easterly (2001)
Accountability	Index	Kaufmann et al. (2009); ICRG
Political Stability	Index	Kaufmann et al. (2009); ICRG
Regulatory Quality	Index	Kaufmann et al. (2009); ICRG
Rule of Law	Index	Kaufmann et al. (2009); ICRG
Judicial independence	Index	Gwartney and Lawson (2009)
Property rights	Index	Gwartney and Lawson (2009)
Credit market regulation	Index	Gwartney and Lawson (2009)
Labour market regulation	Index	Gwartney and Lawson (2009)
Business regulation	Index	Gwartney and Lawson (2009)
Financial development	Various measures	Beck et al. (2000)
Employment Elasticity	Δ Employment / Δ GDP	ILO (2009)
Unemployment	% of population	ILO (2009)
Aid	Total aid / GDP	Roodman (2005)
Education	Various measures	Barro and Lee (2001)
Inflation		ECLAC (2009)
Legal Origin		Porta et al. (2008)
Economic Freedom	Various indices	Holmes et al. (2008)
Political Rights	Index	Freedom House
Civil Liberties	Index	Freedom House
Freedom of the Press	Index	Freedom House
Globalisation	Various Indices	Dreher (2006a)
Democracy	Various indices	Marshall and Jaggers (2007)
Government spending	Government share of real GDP	Heston et al. (2009)

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