Do infrastructure reforms reduce the effect of corruption? Evidence from electricity firms in Latin America*

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Abstract

This paper evaluates the effect of corruption on firms' performance and the potential influence of government policy on this relationship. In particular, we consider the impact of corruption, ownership and institutional governance on the efficiency of a panel of 199 electricity distribution firms across 16 countries in Latin America between 1995 and 2005. We find evidence that higher corruption levels are significantly associated with less efficient firms. However, both the creation by the government of an Independent Regulatory Agency (IRA) and privatisation appear to significantly reduce this effect. Furthermore, the results emphasise the importance of getting governance right when creating an IRA, with agency creation increasing efficiency if regulatory governance is strong, but decreasing efficiency if governance is weak. These results survive a range of robustness checks including separately instrumenting for regulatory governance, ownership and corruption. Overall, we conclude that the creation of well governed regulatory agencies can help to counter high levels of corruption in the country as a whole.

JEL: D73; L33; L51; L94; L98

Keywords: Regulation; Corruption; Privatization; Electricity

1 Introduction

Corruption has been identified as a key factor that may reduce growth and worsen poverty in developing countries.[1] One particular area of the economy where corruption is a major concern is the operation and regulation of network infrastructure such as electricity, telecoms and water. A high level of government

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[1]See, for example, Mauro (1995). Bardhan (1997) provides a survey. As an example of the way in which corruption is damaging to firms performance, Fisman and Svensson (2007) provide evidence that paying bribes decreases firms' growth in Uganda.

intervention and frequent lack of competition make firms in these sectors particularly vulnerable to corrupt behavior.[2] Whilst the empirical work on the issue is limited, there is increasing evidence that corruption can significantly reduce the performance of utilities.[3]

A wish to reduce this corruption has been part of the reason why developing countries have been urged to undertake large-scale reform of their utilities in the last twenty years. In sectors where the introduction of competition is difficult, reform has generally consisted of privatization and improving the institutional environment. Work on this latter aspect of reform has generally been focused on the creation of an Independent Regulatory Agency (IRA) with specific responsibility for regulation of one or more infrastructure sectors. These 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. However, their exact degree of autonomy varies across countries and sectors. Over the last twenty years, the creation of such an agency has come to be seen internationally as a key first step towards improving the institutional environment in which regulated firms operate.

Previous empirical work has attempted to evaluate the effect of privatisation and the creation of an IRA on various performance measures. There is some evidence that privatization has often improved performance, although this has also frequently not been the case.[4] Evidence is also emerging that a key determinant of performance is the institutional environment utility firms operate in, and in particular the quality of regulatory governance. In particular, several studies have shown that performance has been improved by the creation of an IRA that is in some sense separated from the executive. A few of these studies have also tried to gauge the degree to which these agencies are well governed, and here they have found evidence that good regulatory governance also improves the performance of the regulated sector.[5]

This paper aims to contribute to the literature in two ways. Firstly, I wish to add to the evidence on the direct effect of the regulatory environment and ownership by testing the effects that corruption, regulatory governance and ownership have on efficiency. Secondly, I wish to extend this analysis a step further in order to consider how these factors interact. In particular, I aim to investigate whether regulatory governance and ownership may interact with corruption. I carry out the analysis on a sample of electricity distribution firms in Latin America over the period 1995-2005. The electricity distribution

[2]See Dal Bó (2006); Estache and Trujillo (2009); Kenny (2009) for overviews of corruption in regulation and infrastructure

[3]Dal Bó and Rossi (2007); Estache et al. (2009); Estache and Kouassi (2002); Seim and Sreide (2009) provide cross-country empirical evidence of the negative effect of corruption on utility performance. Cubbin and Stern (2006), on the other hand, find no significant effect of corruption on generation capacity. This may be because corruption mitigates commitment problems and hence its effect on efficiency is different from that on long-term investment.

[4]See Boubakri et al. (2008); Megginson and Sutter (2006); Parker and Kirkpatrick (2005) for surveys of the empirical literature on privatization in developing countries. The latter survey in particular argues that the institutional environment plays a greater role in determining performance than in developed countries.

[5]For example, in the telecoms sector (where data is best) Berg and Hamilton (2000); Maiorano and Stern (2007); Ros (2003); Wallsten (2001) find evidence of the positive effect of creating an IRA. Estache and Rossi (2005) finds similar results for the electricity sector. Andres et al. (2008); Cubbin and Stern (2006); Gutiérrez (2003a); Gutiérrez and Berg (2000); Montoya and Trillas (2007); Pargal (2003); Zhang et al. (2008) look at a range of other aspects of regulatory governance and generally find that these also can also have positive effects. Estache and Wren-Lewis (2009) provide a survey of the theoretical literature on the importance of institutions in utility regulation in developing countries.

sector is suitable for analysis of these issues since government regulation is important and direct competition is limited. Moreover, the period and region is one that includes a number of important reforms as well as variation in the level of corruption both within and between countries.

The paper can be regarded as an extension of the empirical part of Dal Bó and Rossi (2007), who use a dataset that is very close to a subset of the data used in this paper. The panel they use contains data on 80 electricity distribution firms across 13 Latin American countries for the years 1994-2004. They construct a labour demand function and find that greater corruption leads to a greater number of employees for a given function of outputs and other inputs. They consider a number of other factors that affect efficiency, including whether the firm is public or private and the level of law and order in the country, but these effects appear to be separate and do not significantly interact with corruption.

Using a similar methodology to Dal Bó and Rossi (2007), I also find evidence that corruption and public ownership decrease efficiency. My results suggest that an increase in the level of corruption in a country by one standard deviation may lead to a 17% increase in the number of workers employed for a given level of outputs, if the firm is public and not regulated by an IRA. I then extend the analysis by introducing regulatory governance into consideration, using data collected by Andres et al. (2007). I find that whist the creation of an independent regulatory agency on its own does not increase efficiency, better regulatory governance significantly increases efficiency. Indeed, the regressions suggest that the creation of poorly governed IRAs has in fact decreased efficiency compared to prior regulation within the government. This result highlights the importance of going beyond stressing solely the need for an independent agency and considering more complex aspects of regulatory governance.

The paper then turns to consider whether privatization or good regulatory governance may mitigate the negative effect of corruption on efficiency. By introducing interaction terms I find evidence that privately managed firms are less affected by national corruption than publicly managed ones. The results suggest that private ownership reduces the negative effect of corruption by about 30 %. Indeed, when the interaction term is introduced, private ownership itself loses significance. Similarly, good regulatory governance significantly reduces the effect of corruption. Firms that are regulated by an IRA appear to be significantly less affected by the amount of corruption in the country than firms who remain directly regulated by the government. Indeed, if regulatory governance is of a high quality, the effect of corruption may be reduced by up to 80 %. I then test for the robustness of these results using several permutations of the baseline equation, including introducing various control variables and instrumenting for corruption, regulatory governance and ownership. Whilst the coefficients on terms including owernship lose significance when we instrument for ownership, the significance of good regulatory governance in mitigating the adverse effect of corruption is robust.

One way of interpreting this result is that the combination of corruption measured at the country level and the sector/firm-level interaction terms proxy the amount of corruption that occurs in the relationship between the firm and the regulator. In this interpretation, a greater level of corruption in the country as a whole increases the corruption between the firm and the regulator, and therefore decreases efficiency. This corruption between the firm and the regulator can then be reduced by improving regulatory governance or privatizing the firm.

There are a few other papers that explore the interaction of corruption and aspects of utility reform. In terms of ownership, Dal Bó and Rossi (2007) find no robust effect of the interaction of corruption and ownership. Taking a different approach, Clarke and Xu (2004) study how firm characteristics influence the frequency with which utilities demand bribes. They find that utility employees are more likely to take bribes in countries with greater constraints on utility capacity, lower levels of competition in the utility sector, and where utilities are state-owned. They do not however look at whether this impacts on other aspects of utility performance.

I have found three papers that interact corruption with the existence of an independent regulatory agency. Estache and Rossi (2008) extend the sample used in Dal Bó and Rossi (2007) to countries outside of Latin America and test the effect of a regulatory agency's existence on efficiency, using corruption as a control. Whilst they find a regulatory agency significantly increases efficiency, the interaction term with corruption is not significant. Estache et al. (2009) consider the impact of corruption, privatization and the existence of a regulatory agency on a range of performance measures and find mixed results. They find privatization and regulatory agencies interact in a positive way with corruption in telecoms, but this is not so clearly the case for electricity. Finally, Guasch and Straub (2009) study the impact of corruption and reforms on the probability of contract renegotiation. They find that corruption increases firm-led renegotiation but decreases government-led renegotiation. The existence of an independent regulator at the awarding of the contract appears to mitigate this first effect and enable the second - i.e. the existence of a regulator in a corrupt environment decreases the probability of renegotiation.

Overall therefore, the previous literature has found some evidence that regulatory reforms can influence the way corruption affects performance, but the results are far from conclusive. Given the results in this paper, one explanation for the insignificance of the interaction term in other work may be the fact that at best regulatory governance is measured by the existence of an independent regulator. Our results emphasize the importance of using data that contains more detailed measures of regulatory governance in further work on this topic.

2 Data and variable definitions

The main data I use consists of three different components: corruption, regulatory governance and firms' inputs and outputs.

Data on corruption is from the International Country Risk Guide, which is collected by Political Risk Services. This is the same dataset as used by Dal Bó and Rossi (2007) and contains annual country-level data since 1970. 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.[6] The ICRG corruption index is meant 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 transform the data such that the index runs between 0 and 1, with 0 representing the lowest possible measure of corruption (i.e. 6 in ICRG) and 1 the highest (i.e. 0 in ICRG). Table 1 gives summary statistics of the variable by country.

Table 1: **Corruption summary statistics by country**

country	**mean**	**sd**	**min**	**max**
Argentina	0.58	0.07	0.50	0.67
Bolivia	0.56	0.08	0.50	0.67
Brazil	0.53	0.09	0.33	0.69
Chile	0.39	0.11	0.25	0.58
Colombia	0.60	0.10	0.50	0.75
Costa Rica	0.32	0.21	0.17	0.64
Dominican Republic	0.56	0.16	0.33	0.67
Ecuador	0.51	0.08	0.43	0.73
El Salvador	0.46	0.11	0.33	0.58
Guatemala	0.34	0.02	0.33	0.36
Honduras	0.65	0.04	0.58	0.68
Jamaica	0.75	0.00	0.75	0.75
Mexico	0.59	0.09	0.43	0.67
Panama	0.67	0.00	0.67	0.67
Peru	0.53	0.07	0.39	0.67
Uruguay	0.50	0.00	0.50	0.50
Total	0.53	0.14	0.17	0.75

Source: International Country Risk Guide.
Data is for years where a firm is present in the sample

The data on regulatory governance is from Andres et al. (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.[7] 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. 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.

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

[6] Two commonly used alternative measures of corruption are those compiled by Transparency International and the World Governance Indicators. The former is not designed for comparison over time, and has slightly less coverage than the ICRG data, whilst the latter has no data for the years 1995,1997 and 1999.

[7] I am very grateful to Luis Andres for allowing me access to this data.

are available publicly and the way in which the head of the agency is appointed (see Andres et al. (2007) for more details). I make use primarily of the Electricity Regulatory Governance Index (ERGI) constructed by Andres et al. (2007), where a rating of 0 represents the worst possible measure of governance and 1 the best.[8] For Argentina and Brazil, I use the ERGI of the provincial regulatory agency where such information exists, and the country ERGI otherwise. 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. Table 2 gives summary statistics of the regulatory governance index (ERGI) and when agencies have been created in each country/province.

Data on firm performance is from the World Bank Latin American and Caribbean Electricity Distribution Benchmarking Database.[9] It contains data on 249 utilities across 25 countries between the years 1995-2005, and overall the firms represent 88 percent of all electricity connections in the region. It is almost a pure extension of the dataset used by Dal Bó and Rossi (2007). 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 Table 3.

In total, these three data sources combine to create a database of 199 firms across 17 countries with a total of 1621 observations (i.e. this is the largest possible intersection of the three datasets). Table 4 shows the number of firms of each type in each country. Of the 199 firms, 63 change ownership over the period (all but one from public to private) whilst 80 begin in the sample without a regulator and then become regulated.

3 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.

As stated by Dal Bó and Rossi (2007), Latin American electricity distribution firms have the obligation to meet demand. For a given firm, I can therefore consider the amount of electricity sold to final customers and the number of final customers served as exogenous outputs.[10]

I therefore follow Dal Bó and Rossi (2007) in estimating a parametric labour requirement function.[11] In particular, I follow their use of a translog functional form because it provides a good second-order approximation to a broad class of functions and they rejected the hypothesis that the function was Cobb-

[8] Of course, notions of 'good' governance are somewhat subjective. In future work, I therefore analyse the extent to which the ERGI is the best measure of governance to use when constructing a total measure from the various components of governance.

[9] This can be found on-line at info.worldbank.org/etools/lacelectricity/home.htm

[10] This assumption is also held in Dal Bó and Rossi (2007).

[11] The idea of input requirement functions goes back to Diewert (1974)

Table 2: **Regulation summary statistics by regulator**

province	**Start year**	**ERGI**
Argentina	1993	.78
Bolivia	1996	.84
Brazil	1997	.86
Chile	1990	.56
Colombia	1994	.76
Costa Rica	1996	.74
Dominican Republic	1998	.75
Ecuador	1999	.61
El Salvador	1997	.82
Guatemala	1996	.79
Honduras	1995	.56
Jamaica	1997	.72
Mexico	1995	.72
Nicaragua	1985	.75
Panama	1996	.63
Peru	1996	.84
Uruguay	2000	.73
Argentinian Provinces		
Cordoba	2001	.68
Fromosa	1995	.52
Jujuy	1996	.64
Rio Negro	1996	.76
Salta	1996	.76
Tucuman	1993	.55
Brazilian States		
Alagoas	2002	.63
Amazonas	2001	.61
Bahia	1999	.73
Ceara	1998	.74
Espirito Santo	2005	.52
Goias	2000	.81
Mato Grosso	1999	.67
Mato Grosso do Sul	2002	.84
Para	1998	.72
Paraiba	2002	.57
Pernambuco	2000	.75
Rio Grande do Norte	1999	.67
Rio Grande do Sul	1997	.69
Sao Paulo	1997	.83
Overal median	1997	.73

Source: Andres et al. (2007)

Table 3: **Summary statistics of firm characteristics**

variable	**mean**	**sd**	**min**	**max**
Employees	1337	3479	12	40970
Connections	668958	1771628	2499	23265575
Electricity (GWh)	3619	11201	3	140283

Source: World Bank

Table 4: **Ownership and regulation of firms**

		Ownership			Regulation		
Country	**Firms**	**Private**	**Public**	**Changed**	**Regulated**	**Unregulated**	**Changed**
Arg Provinces	6	2	1	3	4	0	2
Argentina	30	12	17	1	30	0	0
Bolivia	6	0	0	6	0	0	6
Br States	34	9	4	21	8	1	25
Brazil	21	4	4	13	7	0	14
Chile	22	22	0	0	22	0	0
Colombia	20	0	16	4	20	0	0
Costa Rica	8	0	8	0	4	0	4
Dominican Rep	2	2	0	0	2	0	0
Ecuador	20	0	19	1	11	0	9
El Salvador	5	1	0	4	1	0	4
Guatemala	1	1	0	0	1	0	0
Honduras	1	0	1	0	1	0	0
Jamaica	1	1	0	0	1	0	0
Mexico	2	0	2	0	2	0	0
Panama	3	0	0	3	1	0	2
Peru	16	2	7	7	3	0	13
Uruguay	1	0	1	0	0	0	1
Total	199	56	80	63	118	1	80

Source: World Bank and Andres et al. (2007)

Douglas. 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. Since these variables are likely to vary little over time, I therefore use a firm fixed effects approach to control for time-invariant unobservables.[12]

A translog labour requirement model with two outputs, for a panel of $i = 1, , N$ firms producing in $c = 1, , C$ countries, and observed over $t = 1, , T$ periods, may be specified as

$$l^{i,t} \quad = \quad \alpha_i + \psi_t + \sum_{m=1}^{2} \omega_m y_m^{i,t} + \frac{1}{2} \sum_{m=1}^{2} \sum_{n=1}^{2} \omega_{mn} y_m^{i,t} y_n^{i,t} + \nu_{it} \tag{1}$$

where l, y_1 and y_2 are the natural logarithms of labour, sales and customers 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. To control for potential biases caused by any omitted variables that are country, province or firm specific and time invariant, I include firm fixed effects (α_i). We will then add to this equation a dummy indicating whether the firm is privately owned, a dummy indicating the presence of an IRA, the level of corruption in the country, the ERGI of

[12] To test for the assumption that firm fixed effects are sufficient, I have run the baseline regression over the reduced sample with the length of the distribution lines in the translog function. In the baseline equation all the terms are insignificant and it does not change any results significantly in any of my regressions. 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.

any regulator that exists (which takes a value of 0 if there is no regulator), and appropriate interaction terms.

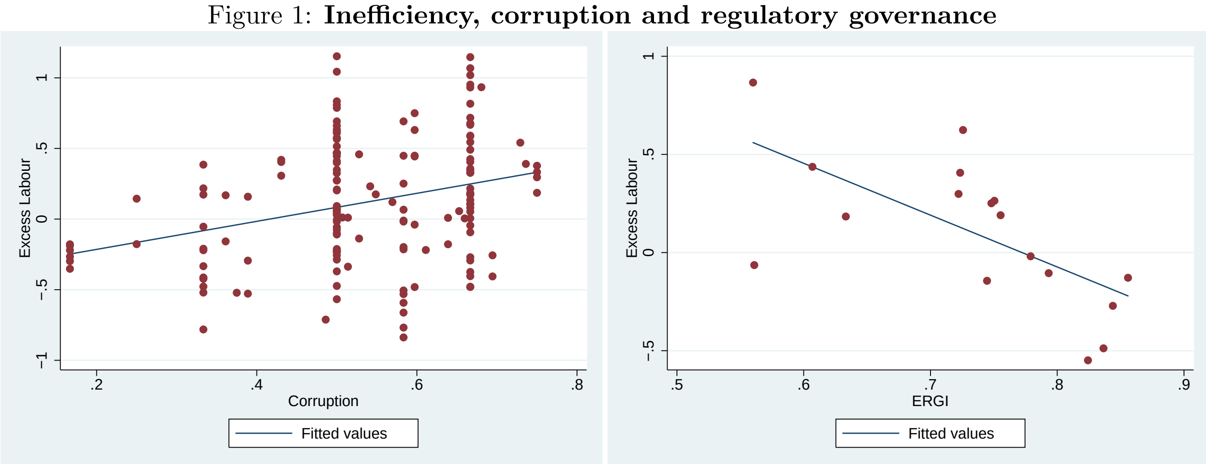
I am therefore using a fixed effects regression. A concern in this type of study is that the shocks affecting all firms in a given country in the same year may be correlated, thus biasing standard error estimates. To address this issue, all standard errors are clustered on country-year combinations, as in Dal Bó and Rossi (2007).

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, we measure inefficiency by regressing the log of employees on the translog function described in (1) and storing the residuals.[13] This thus creates a measure of 'excess labour', which gives us an idea of how efficient the firm is in any year compared to the average of all firms over the whole period. We then collapse the data down to the country level by taking the simple average 'excess labour' of all the firms in a given country for each year. Figure 1(a) plots this measure of excess labour against corruption for each country year pair. Figure 1(b) then plots excess labour against the index of regulatory governance (ERGI), averaging excess labour over the years for which an IRA exists.[14]

Figure 1: **Inefficiency, corruption and regulatory governance**



(a) Excess labour by corruption

(b) Excess labour by ERGI

From the fitted line in Figure 1(a), we can see that there therefore appears to be a positive correlation between corruption and inefficiency. Moreover, from Figure 1(b), inefficiency appears to decrease as regulatory governance improves.

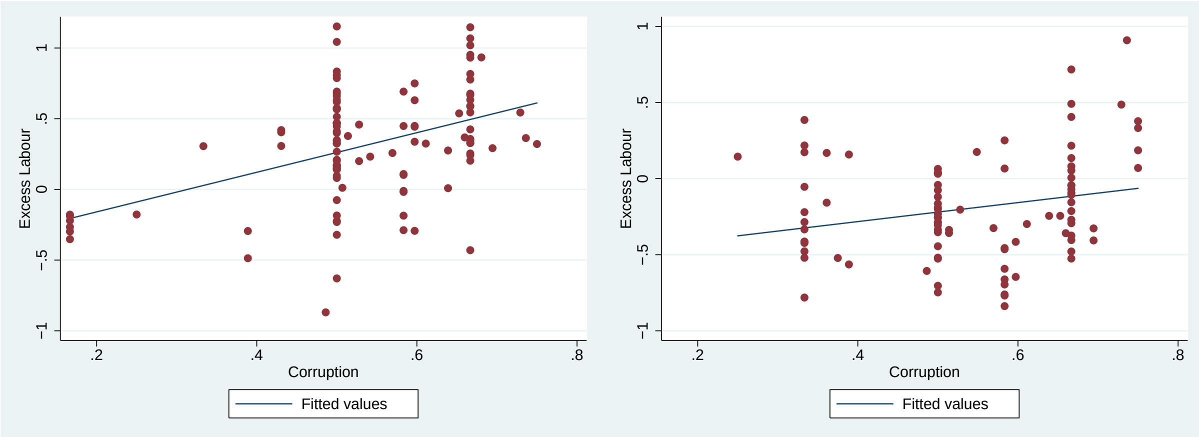
Let us now consider whether either of the reforms - privatization or improved regulatory governance

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

[14] For the purposes of the graphics we consider only national regulators

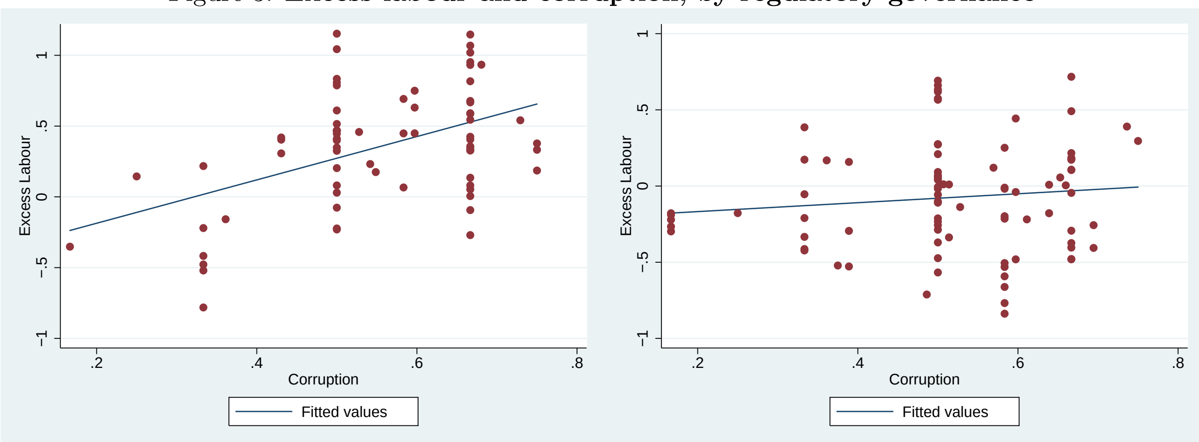
- have an effect on the relationship between corruption and inefficiency. Figure 2 plots excess labour against corruption separately for both public and private firms. Figure 3 then plots the graph separately for the country year pairs where regulatory governance is ‘low’ (i.e. no IRA or an ERGI score below the median) and when regulatory governance is ‘high’ (i.e. an IRA with ERGI score above the median).

Figure 2: **Excess labour and corruption, by ownership**



(a) Public (b) Private

Figure 3: **Excess labour and corruption, by regulatory governance**



(a) ‘Low’ regulatory governance (b) ‘High’ regulatory governance

From these figures, we can see that both reforms appear to affect the relationship between corruption and inefficiency. Whilst in all cases there is a positive correlation between the two variables, this correlation is much smaller in the sample of private firms and in the sample of countries with ‘well-governed’ IRAs. Let us now investigate these effect further through econometric analysis.

4.2 Econometric analysis

Table 5 presents variations of equation (1) specified above. Coefficients on the terms in the translog function are given in Appendix A, and we can note that the coefficients on the translog function are reasonable. The coefficients suggest that if both output measures were to double then the increase in labour required would be 56 %. This suggests the firms have increasing returns to scale, which is what we would expect for the sector. Moreover, it is very close to the value we obtain by using the data from Dal Bó and Rossi (2007), which suggest a doubling of outputs requires a 62 % increase in employees.

Table 5: **Baseline Linear Regression**

	(1)	(2)	(3)	(4)	(5)	(6)
Corruption	0.11*	0.13**	0.12*	0.12*	0.10*	0.11*
	(0.068)	(0.061)	(0.063)	(0.063)	(0.058)	(0.060)
Private dummy		-0.24***	-0.23***	-0.23***	-0.21***	-0.22***
		(0.032)	(0.032)	(0.032)	(0.031)	(0.032)
Regulator dummy			-0.0056		0.72***	
			(0.038)		(0.17)	
ERGI				-0.040	-1.00***	
				(0.048)	(0.23)	
Bad regulator dummy						0.071*
						(0.042)
Good regulator dummy						-0.083**
						(0.036)
Observations	1720	1720	1621	1621	1621	1621
R^2	0.2924	0.3551	0.3694	0.3701	0.3841	0.3782
Number of firms	215	215	199	199	199	199

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

From Table 5 , we can see that the coefficient on the corruption term is consistently positive, which suggests that higher corruption causes a greater number of workers being employed for a given function of outputs. Greater corruption therefore appears to decrease efficiency, and the effect is significant. On the other hand, the coefficient on the private ownership dummy is negative (and significant) across the various specifications, suggesting that private firms are more efficient.

From column (3), we can see that the creation of a regulatory agency does not on average appear to have a significant effect on efficiency. Furthermore, in column (4), we can see that the measure of regulatory governance also appears to have no significant effect. However, when we introduce both the regulator dummy and the measure of governance in column (5), both terms become highly significant. The coefficient on the regulator dummy is significantly positive whilst that on regulatory governance is significantly negative, with the former coefficient being smaller by a factor of 0.72. From Table 2 we can see that this value is roughly the median of the regulatory governance index in the sample. Column (6) presents an alternative way of viewing this result. This column includes two dummy variables measuring regulation - a dummy for an IRA with above-median governance and a dummy for an IRA with below-median governance.

These regressions suggests that only a well governed IRA will increase efficiency, whilst a badly-governed IRA will decrease efficiency, compared to prior direct government regulation. This may be because a bad regulator diverts management time or causes excessive bureaucracy, whilst a well-governed regulator makes sure that regulation encourages efficiency. This result further stresses the need to consider regulatory governance both when setting up an independent regulator and when measuring its effect.

Of these various specifications, I will use column (5) as the baseline for the following exploration of interaction effects. This is because it makes use of the full range of governance values, whilst at the same time controlling for the way we have arbitrarily set regulatory governance to 0 for years before agency creation.

Table 6 then explores interactions between corruption and regulatory governance. Column (1) adds to the baseline equation corruption multiplied by the private ownership dummy, whilst column (2) includes corruption multiplied by the regulatory governance index. Column (3) includes instead corruption multiplied by the IRA existence dummy. In column (4), we include all three terms. In columns (6)-(10) we then include both the corruption * ERGI term and the corruption * Private ownership, testing the robustness of these terms' significance by interacting our terms of interest with a range of dummy variables.[15]

[15] In these columns, the coefficients reported in the space of the interacted terms are the 'average effect'. For example, in column (5), the corruption coefficient is the average affect of corruption across all firms, with the appropriate standard deviation

Table 6: **Linear Regression with Interaction Effects**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Corruption	0.37***	0.85***	0.99***	1.22***	1.10***	1.74***	1.05***	0.76***	0.98***	0.0003***
	(0.082)	(0.20)	(0.19)	(0.17)	(0.16)	(0.08)	(0.08)	(0.27)	(0.17)	(0.00007)
Private dummy	0.016	-0.21***	-0.21***	0.019	0.020	0.40**	0.068	-0.0073	0.003	-0.17**
	(0.074)	(0.031)	(0.031)	(0.074)	(0.075)	(0.18)	(0.079)	(0.070)	(0.032)	(0.081)
ERGI	-0.96***	-0.41	-0.98***	-0.65	-0.38	-0.42	-0.38	-0.013	-0.61*	-0.1
	(0.23)	(0.30)	(0.24)	(0.46)	(0.29)	(0.32)	(0.34)	(0.096)	(0.32)	(0.22)
Regulator dummy	0.68***	0.66***	1.15***	0.88**	0.62***	0.64***	0.61***	0.24	0.78***	0.23*
	(0.17)	(0.18)	(0.36)	(0.18)	(0.21)	(0.18)	(0.15)	(0.20)	(0.15)	(0.14)
Corruption * Private	-0.43***			-0.42***	-0.42***	-1.16***	-0.51***	-0.36***	-0.27**	-0.012
	(0.12)			(0.12)	(0.12)	(0.35)	(0.13)	(0.11)	(0.11)	(0.14)
Corruption * ERGI		-1.05***		-0.54	-1.03***	-1.03***	-1.00***	-0.60	-1.03***	-0.64***
		(0.24)		(0.63)	(0.20)	(0.21)	(0.32)	(0.36)	(0.20)	(0.19)
Corruption * Regulator			-0.90***	-0.48						
			(0.19)	(0.53)						
Regulator * Private										
ERGI * Private										
Corruption * ERGI * Private										
Corruption * firm dummies						Y				
Corruption * year dummies							Y			
ERGI * country dummies								Y		
Private * country dummies									Y	
Corruption * country trends										Y
Observations	1621	1621	1621	1621	1621	1621	1621	1621	1621	1621
R^2	0.3917	0.3911	0.3914	0.3990	0.3985	0.4936	0.4036	0.4268	0.4332	0.4729

Robust standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Overall, we can see that the coefficient on corruption is significant and positive in all the regressions. The coefficient on corruption multiplied by private ownership is significantly negative in most of the columns, suggesting that private firms are less affected by corruption than public firms. Indeed, when this term is included, the coefficient on the private dummy itself becomes positive and (generally) insignificant. This indicates that the greater efficiency of private firms may be largely down to their insulation from the adverse effects of corruption. In other words, private firms would be no more efficient than public ones in a non-corrupt environment. The coefficient on the interaction term however becomes of even greater magnitude when corruption is interacted with the firm dummies. We can therefore deduce that the significance of the interaction term is not just driven by the fact that firms that are private throughout the sample are less affected by corruption than those that are constantly public.

The signs of the ERGI * corruption term is also generally significant and negative, suggesting that good regulatory governance also mitigates the effect of corruption. Indeed, since the introduction of this term results in the insignificance of the ERGI term on its own, this suggests that it is is the main channel through which good governance increases efficiency. It is also worth noting that the coefficient on corruption multiplied by the regulator dummy in column (3) is also negative and significant. When the two terms are both included in column (4) they become individually insignificant, though jointly they are highly significant. This suggests that the two variables are highly correlated (which is of course true) and equally informative. We however continue to use the term where corruption is interacted with ERGI rather than that interacted with the regulator dummy since further analysis suggests it to be slightly more robust.

The only other case where the ERGI x corruption term becomes insignificant is when regulatory governance is interacted with country dummies, 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 p-value is .101. 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. Within the sample, the standard deviation of corruption between countries is .1216451, whereas within countries it is .0821368. The magnitude of the coefficient on the corruption * private interaction is also reduced when we interact ownership with country dummies, though in this case the term remains significant. We also note that, in column (10), the private ownership x corruption term becomes insignificant when we also introduce terms interacting corruption with country time trends (i.e. country dummies multiplied by the year). This suggests that this result may be being driven by a steady improvement in firms' resistance to corruption in countries with private firms.

Let us consider the size of these described effects by considering the coefficients on the variables in column (5). Focusing on the coefficient on corruption, the value of 1.1 suggests that an increase in measured corruption of one standard deviation (.14) produces a 17% increase in the amount of labour employed for a given amount of outputs. This effect is slightly larger than that found by Dal Bó and Rossi (2007). However, this assumes that the firm is publicly owned and not subject to regulation by an IRA. If the firm was private, then this effect is reduced by about 30% increase in the number of employees. Alternatively, if the firm was public but subject to regulation by an IRA with an ERGI of .86 (the highest in the sample), then the effect is reduced by almost 80 %. Our 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 our later sample contains a greater proportion of private firms and firms regualted by an IRA.

Another way of looking at the coefficients is to ask how much the number of employees is reduced by the implementation of privatization or the creation of an IRA. If the level of corruption in the country was relatively low (i.e. at Costa Rica's mean level of .32) then the coefficients suggest that privatization would result in a 10% decrease in the labour force. If, on the other hand, corruption was relatively high (i.e. at Jamaica's mean level of .75), then privatization results in a 25% reduction in employees. In terms of the creation of an independent regulatory agency, introducing a well governed IRA (i.e. ERGI=.86) into the high corruption environment results in a 32% reduction in employees in the high corruption setting. However, in the low corruption setting (.32), the introduction of a well governed IRA has a tiny effect on the number of employees. Moreover, if the IRA is badly governed, then the effect of the creation of an IRA appears to be possibly negative. Even in the high corruption environment (.75), the introduction of a badly governed IRA (i.e. ERGI=.54, the lowest in the sample) only reduces the number of employees by 3%. In the low corruption environment (.32), the coefficients suggest that the introduction of a badly governed IRA results in an increase in the number of employees by 25% relative to the prior direct government regulation.

Of course, all of 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.[16] 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. Indeed, the empirical results indicate that corruption significantly reduces the efficiency of firms, but that this effect can be significantly mitigated by the creation of a well-governed IRA and private ownership. In addition, the effect on efficiency of an independent regulator appears to be dependent on its governance, with a badly governed regulator potentially decreasing efficiency. Let us now consider the robustness of these results by running a series of further checks.

[16]Moreover, as pointed out by Dal Bó and Rossi (2007) and 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 0.2 as an increase from 0.7 to 0.8, for example.

5 Robustness Checks

This section aims to consider whether the results are robust to changes in the assumptions or methodologies, in order to gauge how confident we can be in the results above.

5.1 Extra Control Variables

One concern of 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.

In order to test for omitted variable bias, we need to check that neither ERGI, private ownership nor corruption are proxying for omitted variables. Since in our baseline regression we include ERGI linearly and interacted with corruption, to test for omitted variable bias in these coefficients we include a range of country-level control variables along with a term interacting the control variable with corruption.[17] This includes variables such as GDP per capita, national wage levels and urbanisation. A selection of these variables and their sources are given in Appendix B. Since private ownership is also included linearly and interacted with corruption, this also tests for omitted variable bias in the coefficients on the terms involving ownership.

Running the baseline regression with interactions (column (6) in Table 6) we find that many of these variables and their interactions are significant when introduced. However the corruption * ERGI and corruption * Private terms always remains significant, and we can therefore conclude that these interaction terms are not proxying for any other country level variable.

To test whether corruption is proxying for an alternative variable, I next include each control variable with its interaction with both private ownership and ERGI. 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 x ERGI or corruption X private ownership) become 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 at the same time as the relevant control term becomes significant. For example, if corruption x ERGI were to become insignificant but retain a similar coefficient when GDP per capita and its interactions were introduced, we would only be really concerned if the GDP per capita x ERGI term was significant. If this were not the case, then it is likely just to be that the introduction of other highly correlated variables are reducing the significance of corruption x ERGI term. If the GDP per capita x ERGI term was significant, however, then we may worry that the significance of the corruption x ERGI term in the baseline regression was being driven by the correlation between GDP per capita and corruption.

For almost all of our control variables, this is not the case. On the few occasions where one of the

[17] We do not include other regulatory-level variables as these will be investigated further in future work we explore in more detail what aspects of regulation are driving the results.

corruption terms becomes insignificant, the corresponding control variable term is also insignificant. The only exception is when the number of years since regime change is included along with its interaction terms. However, the number of years since regime change is much higher in Costa Rica than in the rest of Latin America, and this country also generally has much lower than average corruption. If we remove the observations in Costa Rica from our sample the coefficients on all of our corruption terms are significant. Overall therefore, we can conclude that our results are likely to be being driven by omitted variable bias.

5.2 Instrumental Variables

One way to control for any potential endogeneity of the key explanatory variables is to use an instrumental variable approach. Although I believe that problems of reverse causality and omitted variables are not likely to affect the corruption or regulatory governance terms, such possibilities cannot be ruled out. In this section we therefore instrument separately for corruption, regulatory governance and ownership using a variety of instruments.

In terms of corruption, Dal Bó and Rossi (2007) find no evidence that corruption is endogenous, and indeed reverse causality seems unlikely since I am looking at the performance of firms in just one sector and corruption in the entire country. Shocks that affect the whole economy of a country in a specific year are likely to be captured by the use of control variables such as GDP per capita. However, since we cannot rule out the possibility of endogeneity, I check for robustness by instrumenting the measure of corruption.

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. Partly, this is because such a reverse influence is likely to occur over the longer-term and will hence be captured by firm fixed effects. I also believe that the effect of omitted variables is likely to be picked up by the country-level controls used in the previous subsection. Nonetheless, I check for robustness by instrumenting for regulatory governance since I can not completely rule out endogeneity.

Ownership is perhaps the variable most likely to suffer from problems of reverse causality. It may well be that only the most efficient firms are privatized, which would produce a negative coefficient on the private ownership 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 * Private Ownership) term, as we have found above. It is therefore particularly important to attempt to instrument for ownership.

In order to instrument for corruption, I require variables that are correlated with corruption but not directly correlated with firm efficiency. I use two variables to instrument for corruption, since this is useful to test for the validity of each one. The first is the number of years remaining in the government's term, taken from the Database of Political Institutions constructed by Beck et al. (2001). I find this variable to be negatively correlated with corruption, presumably reflecting the tendency of governments to become more corrupt the longer they remain in power. The second variable I use is the proportion of the population with higher education, which I also find to be negatively correlated with corruption. Both 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 x ERGI, term remaining x ownership) we find that they are all insignificant, which suggests that they are valid instruments.

In order to instrument for regulatory governance I require two instruments since I am simultaneously instrumenting for the existence of a regulator and the governance index. I therefore 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.[18] Moreover, firm performance in the electricity sector will almost certainly not influence regulatory governance in other sectors, at least in the short term. For the telecoms sector, I use an index of whether the regulator is funded by a specific tax rather than out of the general government budget, which is constructed by Gutiérrez (2003b). For water, I use a simple dummy which indicates whether an IRA exists regulating the water sector, 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.

Finding valid and informative instruments for private ownership is unfortunately the most difficult, since this is a firm level variable, and the other firm-level variables we have are themselves likely to be endogenous with respect to efficiency or affect efficiency directly. We therefore have to use instruments that are measured at the province or country level. At the province level, we use the number of years since Private Participation in Infrastructure (PPI) has existed in the country/province, excluding the energy sector. 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. This gives us an indication of a province or country's tendency to privatize network infrastructure generally, which should not be affected particularly by the performance of the electricity distribution sector. As a second variable, we use a measure of economic globalisation constructed by Dreher (2006a). This is likely to be positively correlated with privatization since countries that are more open to international finance will find privatization more profitable. Again, both variables and their interaction terms are insignificant when entered as controls into the regression, which reassures us they are valid.

The results of the two-stage least squares regressions are presented in Table 7, where the variables included are the same as in column (5) of Table 6. In column (1), I instrument for the three corruption terms, in column (2) for the regulator dummy, regulatory governance and the corruption x ERGI term and

[18] I am very grateful to Antonio Estache and Luis H. Gutierrez for providing me with access to their data.

in column (3) for private ownership and the corruption x ownership term. In each case, the instruments are interacted with the appropriate variable(s) and these new variables are also included as instruments. For example, in column (3) we instrument for both the private ownership term and the (private ownership * corruption) term, with the instruments being the two described above along with these variables multiplied by corruption. To make this clear, the coefficients of instrumented for terms are displayed in bold. The results of the first stage regressions are reported in the Appendix C.

Table 7: **Instrumenting for Corruption and Regulatory Governance**

	Instrumenting for:		
	Corruption (1)	Regulator & ERGI (2)	Ownership (3)
Corruption	**2.27*****	1.18***	0.98***
	(0.61)	(0.41)	(0.32)
Corruption * ERGI	**-2.50*****	**-1.11****	-0.85***
	(0.85)	(0.51)	(0.28)
Corruption * Private	**-0.26**	-0.46***	**-0.40**
	(0.36)	(0.12)	(0.40)
Private dummy	-0.062	0.061	**-0.17**
	(0.19)	(0.073)	(0.25)
Regulator dummy	0.51***	**0.64**	0.51***
	(0.14)	(0.86)	(0.14)
ERGI	0.48	**-0.49**	-0.25
	(0.51)	(1.22)	(0.24)
Observations	1621	1621	1621
R^2	0.2133	0.2317	0.2016
Number of firms	199	199	199
Kleibergen-Paap Wald rank F statistic	13.5	6.77	17.7
Endogeneity test p-value	0.21	0.19	0.13
Hansen J instrument exogeneity test p-value	0.21	0.12	0.37

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

From Table 7 we can see that the coefficients keep the same sign as in the baseline equation, with most of them remaining significant. The exception is the Corruption * Private ownership term, which is insignificant in columns (1) and (3), when corruption and ownership are being instrumented for respectively. Though this is likely to mainly stem from the weakness of the instruments, it does perhaps suggests that we should be less confident of the positive results of privatization in mitigating the adverse impact of corruption on efficiency than those of good regulatory governance. Overall however, the coefficients suggest that treating the variables as endogenous does not change things substantially.

In the lower rows of Table 7 are the results of various tests of the validity of various assumptions. In order to test whether the instruments are sufficiently strong, the Kleibergen-Paap Wald rank F statistic is calculated. Generally, an F statistic above 10 is considered to imply strong instruments, and hence we can see that in columns (1) and (3) the instruments for corruption and ownership are strong. The instruments for regulatory governance are not so strong, although they are sufficiently strong such that the standard test of under-identification is rejected.[19] The weakness partly reflects the difficulty of instrumenting for three different terms, namely the IRA dummy term as well as ERGI and its interaction with corruption.

One advantage of instrumenting with more instruments than endogenous explanatory variables is that we can test the validity of the instruments using the Sargan-Hansen test. The joint null hypothesis under this test is that the instruments are valid, i.e., uncorrelated with the error term. The p-statistic 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 private ownership index are indeed exogenous. To do so, the difference of two Sargan-Hansen statistics is calculated, one for the equation where the variables are instrumented, and one for the non-instrumented equation. 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 and regulatory governance can be treated as exogenous. Alternatively, we 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 not sufficient evidence to reject the null hypothesis of non-systematic differences in the coefficient. I therefore conclude that it is reasonable to treat all of the variables as exogenous.

5.3 Ownership differences

A further question of robustness is whether the results above apply to firms in both the public and private sectors. Table 8 shows the result of six regressions where we split the sample by ownership. Columns (1) to (3) consider a simplified version of the baseline equation without ERGI - corruption is instead interacted with the ownership dummy and the IRA dummy. Columns (4) to (6) then reintroduce ERGI and the term interacted with corruption. In each case, the first of the three columns contains all firms, whilst the second contains private firms and the third public firms. Firms whose ownership changes over the period are split appropriately - those years in which they are privately owned are included in the second column, whilst those years during which they were publicly owned are included in the third column.

Looking at columns (1) to (3), we can see that the results appear very similar for both private and public firms. For both types of firm corruption increases inefficiency and this effect is significantly reduced if there is an IRA present. The coefficients on the terms are fairly similar, though the coefficients on the corruption terms are slightly smaller in magnitude for private firms. This reflects our earlier result that corruption appears to be less damaging for private firms. However, when we introduce ERGI and

[19] Indeed, the LM test of underidentification has a p-value of less than 0.001 for all of the regressions

Table 8: **Ownership differences**

	(1) All	(2) Private	(3) Public	(4) All	(5) Private	(6) Public
Corruption	1.25***	1.05***	1.21***	1.15***	1.03***	1.07***
	(0.25)	(0.37)	(0.23)	(0.22)	(0.39)	(0.16)
Regulator dummy	0.50***	0.60***	0.40***	1.15***	0.57	0.19
	(0.13)	(0.20)	(0.11)	(0.39)	(0.37)	(0.52)
ERGI				-0.94*	0.025	0.23
				(0.51)	(0.45)	(0.71)
Corruption * Regulator	-1.17***	-0.96**	-0.93***	-0.68	-1.33***	1.21
	(0.24)	(0.39)	(0.21)	(0.60)	(0.47)	(0.83)
Corruption * ERGI				-0.56	0.54	-2.84**
				(0.73)	(0.48)	(1.08)
Observations	1621	829	792	1621	829	792
R^2	0.3281	0.2810	0.2798	0.3517	0.2831	0.3213
Number of firms	199	119	143	199	119	143

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

the interaction between ERGI and corruption in columns (4)-(6) we note a significant difference. In the full sample, we see that neither the corruption * regulator term nor the corruption * ERGI term is individually significant, as we found earlier in column (4) of Table 6. However, amongst private firms, the corruption * regulator term is strongly significant whilst the corruption * regulator term is insignificant, suggesting that for private firms it is the creation of an IRA that is important, not how well it is governed. On the other hand, for public firms, the opposite occurs, with governance appearing to be the key factor in mitigating the effect of corruption. Thus, whilst it is clear that an IRA is important in reducing the effect of corruption for both types of firm, the importance of good governance appears to vary, at least as measured by the ERGI. This will be investigated further in future work where we explore the breakdown of regulatory governance in more detail.

5.4 Serial correlation

The model above is static, in that it only allows for variables at the current moment in time to affect current efficiency. If variables are correlated over time, then such a model may be inappropriate. To consider whether serial correlation in the residuals affects the results, we can cluster standard errors at the firm level, which allows for the error term to be correlated within these clusters. Table 9 presents the results of clustering by firm in the second column, with the first column repeating the results of column (5) in Table 6 for comparison.

Clearly, allowing for serial correlation only affects the estimated standard errors, and not the values of the coefficients. From Table 9, we can see that the significance of the coefficients do not change

Table 9: **Serial correlation**

	(1)	(2)
Corruption	1.10***	1.10***
	(0.16)	(0.18)
Private dummy	0.020	0.020
	(0.075)	(0.068)
Regulator dummy	0.62***	0.62**
	(0.18)	(0.25)
ERGI	-0.38	-0.38
	(0.29)	(0.35)
Corruption * ERGI	-1.03***	-1.03***
	(0.20)	(0.25)
Corruption * Private	-0.42***	-0.42***
	(0.12)	(0.11)
Observations	1621	1621
R^2	0.3985	0.2403
Number of firmcode	199	199
r2_a	0.39	0.12

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

substantially. We can therefore infer that our result is robust to the presence of serial correlation in the residuals.

5.5 Alternative estimation techniques

To help understand the results further, I carry out the baseline regression using alternative estimation techniques. Table 10 presents four regressions. Column (1) is the baseline equation estimated using the fixed effects estimator (i.e. as column (5) in Table 6), column (2) uses the random effect estimator and column (3) considers between effects. Finally, column (4) runs the regression as a pooled ordinary least squares (OLS).

From Table 10, we can see that under the random effects model all the reported coefficients remain significant, as they are using pooled OLS. Indeed, the coefficients shown in Table 10 are very similar in the fixed effects and the random effects models. However, this is not the case with the (unreported) coefficients on the translog function. Given the large variation in firm size, this is not surprising. As a result, a Breusch-Pagan Lagrangian multiplier test for random effects therefore rejects the null hypothesis that the random effects model is consistent and hence supports our decision to use a fixed effects approach.

In the between effects model in column (3), all the reported coefficients are insignificant. This suggests that our previous results are driven by changes within firm's efficiency levels more than differences in efficiency between firms.

Table 10: **Alternative estimation techniques**

	FE (1)	RE (2)	BE (3)	OLS (4)
Corruption	1.10***	1.12***	-2.84	2.03***
	(0.16)	(0.18)	(4.10)	(0.47)
Private dummy	0.020	-0.011	-0.0017	-0.039
	(0.075)	(0.080)	(0.57)	(0.14)
Regulator dummy	0.62***	0.70***	-0.0031	0.75***
	(0.18)	(0.19)	(0.48)	(0.18)
ERGI	-0.38	-0.47	-3.35	-0.53
	(0.29)	(0.30)	(3.25)	(0.47)
Corruption * ERGI	-1.03***	-1.05***	5.32	-1.50**
	(0.20)	(0.22)	(6.12)	(0.67)
Corruption * Private	-0.42***	-0.43***	-0.80	-0.82***
	(0.12)	(0.13)	(1.08)	(0.24)
Observations	1621	1621	1621	1621
R^2	0.3985		0.8856	0.8731
Number of firms	199	199	199	

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

5.6 Alternative RHS variables

One concern of the analysis above is that the results may be sensitive to the particular measures of governance and corruption used. Table 11 therefore displays the results of several regressions carried out with different variables on the right hand side. Column (1) replaces ERGI with a good regulator dummy that equals one if the firm is regulated by a regulator with an above median value of the governance index. This helps to control for the possibility that the results are being driven by the extreme values of outliers. Column (2) similarly replaces the corruption measure with a dummy that equals one if and only if corruption is higher than the median corruption level in the sample. Column (3) then introduces the measure of corruption constructed by Transparency International (TI), notwithstanding that this measure is not designed to be used to make comparisons over time. In order to make comparison between this measure of corruption and the previously used one easier, we use a rescaled version of the TI measure that potentially varies between 0 and 1, with 1 representing the highest level of corruption.

From Table 11, we can see that the significance and signs of the coefficients on the corruption terms are fairly robust to these changes in the right hand side variables. In the regressions using binary variables in columns (1) and (2), all the terms involving corruption remain significant, suggesting that these are not being driven by extreme values of corruption or ERGI. Using Transparency International's measure of corruption, the corruption term and its interaction with private ownership remain significant.

Table 11: **Alternative RHS variables**

	(1)	(2)	(3)
Private dummy	0.034	-0.065	0.28
	(0.078)	(0.056)	(0.18)
Regulator dummy	0.042	0.58***	0.58***
	(0.042)	(0.20)	(0.17)
Corruption	0.61***		
	(0.13)		
Good regulator dummy	0.025		
	(0.094)		
Corruption * Private	-0.47***		
	(0.13)		
Corruption * Good regulator	-0.33**		
	(0.13)		
High corruption dummy		0.23***	
		(0.060)	
ERGI		-0.68**	-0.68
		(0.29)	(0.46)
High Corruption * Private		-0.15***	
		(0.053)	
High Corruption * ERGI		-0.16**	
		(0.079)	
TI Corruption			0.92**
			(0.38)
TI Corruption * Private			-0.78**
			(0.30)
TI Corruption * ERGI			-0.24
			(0.48)
Observations	1623	1623	1518
R^2	0.3908	0.3957	0.4139
Number of firms	200	200	200

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5.7 Alternative LHS variables

In the baseline regression, we have measured efficiency by estimating a labour requirement function. A simpler method would be to use a LHS variable that itself proxies efficiency. Two potential variables are the number of MWh sold per employee and the number of residential connections per employee. Using these measures has the disadvantage that we are essentially assuming a more restrictive functional form for the labour requirement function, but may be a useful robustness check if we are concerned about the potential endogeneity of the output variables.[20] The results of using this approach can be seen in Table 12. In these regressions, we no longer include a translog function on the RHS - hence the only variables

[20]This approach is closer to that used in Andres et al. (2008).

included are those reported along with year dummies.

Table 12: **Alternative LHS variables**

	ln(MWh/l) (1)	ln(Connections/l) (2)
Corruption	-0.81***	-1.22***
	(0.26)	(0.15)
Private dummy	0.21**	-0.0084
	(0.11)	(0.084)
Regulator dummy	-0.81***	-0.69***
	(0.24)	(0.19)
ERGI	0.54	0.42
	(0.37)	(0.29)
Corruption * Private	0.083	0.46***
	(0.18)	(0.13)
Corruption * ERGI	1.04***	1.19***
	(0.28)	(0.20)
Observations	1612	1612
R^2	0.5071	0.6067
Number of firms	197	197

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

When looking at Table 12, we should note that we would expect the signs on the coefficients to be reversed compared to our earlier regressions. This is because earlier we were measuring the effect of these variables on labour given various outputs (i.e. inefficiency) whereas here we are measuring their effects on the amount of output produced per worker (i.e. efficiency). Looking at Table 12, we see that this is indeed generally the case. In both regressions, corruption has a significant negative effect on the efficiency measure, and this effect is significantly reduced by the presence of an IRA with good governance. We also find, as before, that private ownership significantly improves efficiency. However, in column (1), when the log of the MWh produced per employee is on the LHS, this effect appears to occur independent of the level of corruption. Nonetheless, the regressions suggest our results are in general robust to the precise way we have measured labour efficiency.

5.8 Other robustness checks

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

- Carrying out the regressions without individual years or countries in the sample, to check that the results are not being driven by a particular country or year
- Shifting forward the year in which the regulator comes into existence, to consider the fact that a regulatory may become operational only sometime after its official creation

- Replacing the variable MWh sold with (MWh sold + losses), to reflect the fact that the amount of electricity lost varies between firms
- Using a Cobb-Douglas function rather than the translog used above
- Including the length of the distribution network in the translog function
- Weighting by firm size and splitting 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 * ERGI and Corruption * Private terms remain significant with the expected signs.

6 Conclusions and Future Work

In conclusion, the empirical analysis has delivered four main results.

First, corruption at the national level appears to have a significantly negative effect on the efficiency of the electricity distribution firms in the sample. The results suggest that an increase in the level of country-wide corruption by one standard deviation may lead to a 17% increase in the number of employees needed for a given level of outputs, if the firm is public and not regulated by an IRA. This result confirms that of Dal Bó and Rossi (2007) and adds to the increasing evidence that corruption can be detrimental for the performance of utilities.

Second, the effect of corruption on efficiency is smaller for private firms than public ones by about 30%. Though this suggests that privatization may be a way to reduce the negative effect of corruption, we should be cautious when making this prediction, since the significance of this result disappears when we attempt to control for the possible endogeneity of private ownership.

Third, the introduction of an Independent Regulatory Agency may reduce the effect of corruption by almost 80 % if the regulatory agency is well governed. This result is robust to controlling for firm specific corruption effects and instrumenting for both corruption and regulatory governance.

Fourth, the efficiency of firms appears to depend directly on the quality of regulatory governance. Indeed, the results suggest that the creation of an IRA that is badly governed may even damage efficiency relative to direct government regulation. This emphasizes the need to go beyond focusing solely on the existence of an agency when measuring the effect of reform.

These results are interesting as they demonstrate the importance of the institutional environment on firm performance. Moreover, they show that negative effects of the general macro institutional context (in this case corruption) can be significantly reduced with well-designed micro-level institutions (in this case electricity regulators). This is a promising result because it adds hope that there are effective ways that the problems caused by corruption can be reduced.

Two avenues for further work present themselves in light of the results I have obtained in this paper. First, it would be useful to extend the analysis to consider other aspects of performance. For example, does corruption have negative effects on quality or price, and if so how does this interact with regulatory governance? Second, it would be interesting to explore further whether the positive effect of regulatory governance found above is down to any particular component of the measure. Existing data in the datasets used here should be usable in investigating both of these questions.

Appendix A: Estimating the translog function

Table 13: **Translog function**

y_1	-0.61
	(0.42)
y_2	4.79***
	(0.69)
$y_1 y_2$	0.025
	(0.070)
y_1^2	0.029
	(0.037)
y_2^2	-0.18***
	(0.041)
Observations	1621
Number of firms	199
R^2	0.3104

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix B: 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	Cingranelli and Richards (2009); Teorell et al. (2009)
Government deficit	% of GDP	Easterly (2001); Teorell et al. (2009)
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)

Appendix C: First stage regressions for instrumenting

Table 14: **Linear Regression with Interaction Effects**

	(1) Corruption	(2) Cor*Pri	(3) Cor*ERGI	(4) ERGI	(5) Reg	(6) Cor*ERGI	(7) Private	(8) Cor*Pri
Private dummy	-0.085	0.40***	-0.082*	0.29***	0.41***	0.10***		
	(0.056)	(0.047)	(0.042)	(0.045)	(0.063)	(0.023)		
Regulator dummy	0.044	0.0070	-0.0028				-0.55***	-0.35***
	(0.062)	(0.052)	(0.046)				(0.16)	(0.089)
ERGI	-0.13	0.065	0.63***				0.36	0.17
	(0.10)	(0.087)	(0.078)				(0.28)	(0.16)
Corruption				0.45***	0.71***	0.63***	-2.07***	-1.19***
				(0.12)	(0.16)	(0.059)	(0.59)	(0.33)
Corruption * Private				-0.36***	-0.56***	-0.098**		
				(0.080)	(0.11)	(0.040)		
Term years left	-0.0035	0.0078	0.011***					
	(0.0058)	(0.0048)	(0.0043)					
ln(fraction with higher education)	-0.64***	-0.14*	-0.39***					
	(0.097)	(0.081)	(0.073)					
Term years left * Private	0.0031	-0.020***	0.00079					
	(0.0036)	(0.0030)	(0.0027)					
ln(fraction with higher education) * Private	0.036	0.073***	0.039**					
	(0.023)	(0.019)	(0.018)					
Term years left * Corruption	-0.018**	-0.0063	-0.030***					
	(0.0081)	(0.0067)	(0.0060)					
ln(fraction with higher education) * ERGI	0.044	-0.034	-0.040					
	(0.034)	(0.028)	(0.026)					
Telecoms regulator tax				0.40***	0.49***	0.090***		
				(0.047)	(0.065)	(0.023)		
Water regulator				0.17***	0.31***	-0.046*		
				(0.056)	(0.077)	(0.028)		
Corruption * Telecoms reg tax				0.028	0.035	0.23***		
				(0.085)	(0.12)	(0.042)		
Corruption * Water reg				-0.31***	-0.49***	0.00064		
				(0.081)	(0.11)	(0.040)		
Corruption * ERGI							1.32***	0.84***
							(0.32)	(0.18)
Years since first PPI							-0.0087***	-0.0053***
							(0.0022)	(0.0013)
Economic Globalisation							0.0054	0.00053
							(0.0055)	(0.0031)
Corruption * Years since PPI							0.0035	0.0043**
							(0.0035)	(0.0020)
Corruption * Globalisation							0.015*	0.016***
							(0.0093)	(0.0053)
Observations	1621	1621	1621	1621	1621	1621	1621	1621
R^2	0.0886	0.7904	0.6420	0.3036	0.2626	0.5754	0.2048	0.3172

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