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Regulatory Agencies:

Impact on Firm Performance and Social Welfare

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Abstract

The authors explore the relation between the establishment of a regulatory agency and the performance of the electricity sector. The authors exploit a unique dataset comprising firm-level information on a representative sample of 220 electric utilities from 51 development and transition countries for the years 1985 to 2005. Their results indicate that regulatory agencies are associated with more efficient firms and with higher social welfare.

This paper—a product of the Economics Unit of the Finance, Economics and Urban Department of the Sustainable Development Network (SDN) of the World Bank—is part of a larger effort in the department to increase the understanding of the ways in which regulatory reforms, including institutional reforms, impact the outcome in regulated infrastructure industries. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at aestache@worldbank.org.

Regulatory Agencies: Impact on Firm Performance and Social Welfare[*]

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1. Introduction

Until the 1990s, most infrastructure utilities were self regulated or under the control of a Ministry, with tariffs and employment reflecting political concerns much more than the efficiency and financial sustainability of service delivery. Average tariffs seldom recovered costs and employment was generally well in excess of what was needed to ensure the efficient service delivery. By maintaining tariff below costs or imposing employment levels, politicians were buying short term political gains, but were also impeding the ability of the sector to generate enough cash to expand as needed while maintaining the financial viability of the operations. In this context, one of the main objectives of the reforms of the 1990s was to reduce political interference with the operation of utilities. The creation of independent regulators was central to an effort that in many cases also involved some kind of private involvement in the operation.[1]

The establishment of an independent regulatory agency was viewed as a strong signal of the government's commitment to replace political considerations by economic concerns. Independent regulators are expected to be capable of monitoring the performance of individual operators without interference from operators or from government. On the one hand, independence would allow regulators to keep politicians at a safe distance of the control of prices, quality, and quantities of services. On the other hand, independence would allow regulators to penalize operators, whether private or public, for failures to deliver on their explicit or implicit contractual commitments.

[1] Estache and Goicoechea (2005) show that the proportion of countries with an independent regulatory agency in the electricity sector increased from 4% in 1990 to 54% in 2004, while the proportion of countries with private involvement in the operation of distribution companies in the same period increased from 4% to 37%.

The main purpose of this paper is to investigate the connection between the creation of regulatory agencies and the performance of electricity operators in developing and transition countries. Our hypothesis is that, compared to self-regulation or control by a Ministry, a regulatory agency can do a better job at monitoring electricity distribution companies and can take remedial action if necessary. More specifically, regulatory agencies are expected to set tariffs that are in line with efficient costs, to ensure that minimum quality-of-service standards are met, and to enforce the targets for connection of new customers imposed by the governments.

The hypothesis of potential performance improvements associated to the creation of an independent regulator for infrastructure industries has been debated for over 10-15 years now (see Kessides, 2004). The empirical literature on the impact of reforms on the performance of individual operators, however, has mainly focused on the impact of privatization.[2]

We investigate the connection between regulatory agencies and the performance of operators in the electricity distribution sector. Our empirical analysis takes advantage of a unique dataset that allows disentangling the impact of establishing a regulatory agency from the impact of private participation in a context in which increased private participation has been quite significant.

We first focus on the impact of regulatory agencies on firm efficiency as approximated by a labor requirement function. We then check the robustness of our

[2] Megginson and Netter (2001) provide a survey of empirical studies on privatization. More recently, Andres et al. (2006) propose a very thorough assessment of the impact of privatization on various dimensions of performance of Latin American electricity distribution companies. Gassner et al. (2006) evaluate the connection between reforms and performance in developing and transitional countries (emphasizing the impact of privatization) by using partial performance indicators. Estache and Rossi (2005) focus on the impact of regulatory regime rather than institutions. Zhang et al. (2005) study the impact of reforms in developing countries in the electricity generation sector, emphasizing on the sequencing of reforms. Guasch (2004) studies the impact of regulatory agencies on the odds of renegotiation.

results by analyzing firms' performance in terms of partial indicators such as workers per connection, operating expenditures, and energy losses. Of course, the regulator is of limited use to the users if improvements on the supply side do not translate into improvements in the service received by the users. To track this we use three measures of social welfare: service coverage, frequency of interruptions, and residential tariffs.

The plan for the paper is as follows. Section 2 describes the dataset. Section 3 presents the econometric model. Section 4 shows the empirical results and provides evidence of their robustness. Finally, Section 5 concludes.

2. Data

We exploit a unique dataset comprising firm-level information on 220 electric utilities from 51 development and transition countries for the period 1985 to 2005. The dataset includes the following variables: total electricity sold (in MWh), total number of connections in the utility area, total number of residential connections in the utility area, length of distribution network (in kilometres), total number of employees, operation expenditures (OPEX, in US dollars), average residential tariff (in US dollars), electricity losses due to technical and non-technical reasons (as a proportion of total electricity sold), frequency of interruptions (number per year), service coverage in the utility area, a dummy variable that takes the value of one if the firm is under the control of a regulatory agency (for more than six months), and a dummy a variable that takes the value of one if the firm received private participation (for more than six months). We define private participation as a situation where the private operator has control over the operation of the utility. We have also information on a set of country-level covariates including corruption, as measured by the Corruption Index produced by International Country Risk Guide (which ranges

between six -highly clean- and zero -highly corrupt-); quality of the bureaucracy, as measured by the Bureaucracy Quality Index produced by International Country Risk Guide (which ranges between four -high quality- and zero -low quality-); the stock of the external debt (outstanding and disbursed, in US dollars); GDP per capita (in US dollars); a political dummy variable that takes the value of one if the country is under an IMF agreement; and population density. Summary statistics are presented in Table 1.

Our sample is representative of the energy sector in development and transition countries. It covers the following countries: Argentina (22 firms supplying electricity to approximately 75% of the total number of customers in the country), Azerbaijan (5, 100%), Belize (1, 100%), Bolivia (7, 88%), Botswana (1, 100%), Brazil (57, 99%), Burkina Faso (1, 100%), Cameroon (1, 100%), Cape Verde (1, 100%), Central African Republic (1, 100%), Colombia (11, 74%), Costa Rica (8, 100%), Czech Republic (8, 84%), Djibouti (1, 100%), Ecuador (20, 100%), El Salvador (5, 100%), Eritrea (1, 100%), Estonia (1, 85%), Ethiopia (1, 100%), Georgia (1, 32%), Ghana (1, 100%), Guatemala (3, 100%), India (5, 20%), Ivory Coast (1, 100%), Kenya (1, 100%), Malawi (1, 100%), Malaysia (2, 99%), Mali (1, 100%), Mauritania (1, 100%), Mauritius (1, 100%), Mexico (2, 100%), Moldova (5, 100%), Morocco (1, 81%), Mozambique (1, 77%), Namibia (1, 20%), Nicaragua (2, 99%), Niger (1, 100%), Panama (3, 100%), Paraguay (2, 100%), Peru (15, 96%), Philippines (1, 20%), Poland (2, 23%), Russia (3, 4%), Senegal (1, 100%), Slovak Republic (3, 100%), South Africa (1, 99%), Tanzania (1, 96%), Uganda (1, 99%), Uruguay (1, 100%), Zambia (1, 100%), and Zimbabwe (1, 100%).

3. Methodology

The objective is to identify the impact of introducing a regulatory agency on firm performance and social welfare in the electricity sector in developing and transition countries.

Our empirical analysis takes advantage of the fact that in the past two decades not all developing and transition countries introduced regulatory agencies and that those countries that introduced regulatory agencies did it at different moments of time, thus providing variation across time and space that we propose to use in order to identify the causal effect of the introduction of regulatory agencies on firm performance and social welfare.

The distribution of firms according to their regulation and ownership status at the end of the sample period is summarized in Table 2. The sequencing of the reforms in countries covered by our sample is summarized in Table 3. There are 38 firms (operating in 11 countries) for which private participation arrived before the regulatory agency was established, 54 firms (operating in 17 countries) for which the regulatory agency was established before private participation, and only 17 firms (operating in four countries) for which private sector participation arrived during the same year in which the regulatory agency was established. The observed variation in the sequencing of the reform process allows disentangling the impact of establishing a regulatory agency from the impact of private participation.

A methodological concern in this type of study is that governments choose whether to introduce a regulatory agency and that choice may be correlated to unobservable factors that also affect performance and welfare. A common method of controlling for time-invariant unobserved heterogeneity is to use panel data and to estimate a difference-in-differences model. Formally, the difference-in-differences model may be specified as

$$Y_{it} = \beta D_{it} + \lambda X_{it} + \alpha_i + \mu_t + \varepsilon_{it} \qquad (1)$$

where Y_{it} is the natural logarithm of the output of interest (labor, operating expenditures, service coverage, quality of service, energy losses, or tariffs) for firm *i* in period *t*, X_{it} is a set of regressors, D_{it} is a dummy variable that takes the value of one if firm *i* operates under the control of a regulatory agency during period t, α_i is a time-invariant firm effect, μ_t is a time effect common to all firms in period *t*, and ε_{it} is a firm time-varying error distributed independently across firms and time and independently of all α_i and μ_t. The parameter of interest, β, is the difference-in-differences estimate of the average effect of introducing a regulatory agency on the output of interest.

4. Results

Our first set of estimations focuses on firm efficiency. Consistent with the literature on the estimation of the relative efficiency of electric utilities, the model proposed here includes a variable input (the number of employees), an exogenous capital input (the kilometers of distribution network), and two exogenous outputs (the total number of connections and the total energy supplied to final customers).

As observed by Kumbhakar and Hjalmarsson (1998) productivity in distribution is, to a large extent, driven by management and efficient labor use; accordingly, the concept of efficiency used through this study is labor-use efficiency (labor productivity): a firm is inefficient if it uses more labor to produce a given bundle of outputs than an otherwise efficient firm would. Our goal, then, is to explain the determinants of labor use, including a variety of technological factors, the characteristics of service, the presence of a regulatory agency, and a set of controls.

In general, electricity distribution firms have the obligation to meet demand; therefore we consider the amount of electricity sold to final customers and the number of connections as exogenous outputs. In many applications service area is included as an exogenous output in the econometric model. Being constant over time, in our model service area is captured by the individual effect.

The number of employees is our measure of labor input. The only capital input in our model is the length of the electricity network in kilometers. As noted by Neuberg (1977) and Kumbakhar and Hjalmarsson (1998) distributors have limited control over the length of distribution lines, since the amount of capital embodied in the network reflects geographical dispersion of customers rather than differences in productive efficiency. Therefore, we treat distribution lines as an exogenous capital variable representing the characteristics of the network.

The electricity technology is represented by means of a labor requirement function. We use a translog functional form because it provides a second-order approximation to a broad class of functions. The translog labor requirement function may be specified as

$$Y_{ict} = \beta D_{it} + \sum_{k=1}^{3} \lambda_k X_{k,it} + \frac{1}{2} \sum_{k=1}^{3} \sum_{n=1}^{3} \lambda_{kn} X_{k,it} X_{n,it} + \alpha_i + \mu_t + \varepsilon_{it} \qquad (2)$$

where Y, X_1, X_2, and X_3 are the natural logarithms of labor, sales, connections, and distribution lines.

We expect regulatory agencies to have a positive impact on labor productivity for both public operators and private operators $(\beta < 0)$. Public operators may be thought as having the objective of delivering energy subject to a constraint of minimum employment and maximum price. In practice, there has been little accountability for the outcomes associated to this optimization program simply

because self regulation or regulation by the political process allowed public operators to avoid this accountability. By getting an independent monitoring of the performance of operators, the creation of a regulatory agency increases the accountability for the quality and quantity of service, reducing the scope for inefficient employment levels. Thus, the creation of a regulatory agency allows public operators to run employment decisions much more in line with a profit maximizing criteria, leading to a reduction in labor requirements. The underlying story is different for private operators. The idea of non-regulated monopolists being inefficient has been there for a while. For instance, Hicks (1935) argues that the best of all monopoly profits is a quiet life. On the same grounds, Hart (1983) suggests that the lack of relevant benchmarks for comparing managerial performance in monopoly markets may be the cause of managerial slack. If this were the case, the introduction of a regulator would push private operators to minimize costs and hence to reduce employment.

Ordinary Least Squares estimates of Equation (2) are reported in Table 4. A typical concern when using difference-in-differences is the potential problem of serial correlation, which results in biased standard errors and generates over-rejection (Bertrand et al., 2004). In order to address this concern we report standard errors clustered at the firm level.

As usual for translog function approximations, the outputs and the capital input have been mean corrected; therefore, the first-order coefficients are elasticities evaluated at the sample mean. The first-order output coefficients are statistically significant and have the expected signs regarding economic behavior: an increase in outputs is associated with an increase in the use of labor. The time dummies are statistically significant in all models and imply an average rate of labor productivity growth in the sector of about 3.5% per year. Overall, estimates regarding

technological parameters are in line with the specialized literature on electricity distribution, yielding further confidence to the validity of the estimation strategy.

The first column of Table 4 reports the labor-requirement difference-in-differences model without controls, apart from firm fixed effects and year dummies. The coefficient on the regulatory agency dummy variable is negative and statistically significant. The coefficient is also significant in economic terms: firms operating under the control of a regulatory agency use about 9.5% less labor to produce a given bundle of outputs.

Our use of energy sold as a measure of output might bias our estimates if the presence of a regulatory agency is correlated with energy losses. As pointed out by Bagdadioglu et al. (1996), network losses reflect the quality of the network system in terms of how much power is lost in the transformers and during distribution, and how much power is uncounted due to other reasons, such as illegal use. Technical losses are related to the square of the distance transmitted, and hence our econometric model captures them. Our main concern is related to non-technical losses associated to illegal use. In order to address the problem of whether including network losses have any impact on the estimated coefficients we replace “sales” by “sales + energy losses”. As shown in Column (2), the coefficient on regulatory agency is still significantly associated to lower labor requirements.

In order to control for ownership type, in Column (3) we include an indicator variable that takes the value of one if the firm is privately owned and zero otherwise. The negative and statistically significant association between the private dummy variable and labor efficiency suggests that private firms outperform public firms. The negative and significant association between the regulatory agency dummy variable and labor persists, though the coefficient is lower than the one obtained in the model

without controlling for private ownership. The magnitude of the estimated coefficients suggests that private participation has more impact on labor requirements than the establishment of a regulatory agency.

To further explore the effects of the reform process we interact the regulatory agency dummy with the private dummy. As shown in Column (4) the interaction effect is not significant, suggesting that there is no differential impact of regulatory agencies on labor efficiency according to ownership type.

In Column (5) we include the proportion of residential connections as an environmental variable that should capture the effect of delivering energy to different type of customers. The proportion of residential connections is not significant at any of the usual confidence levels and it appears not to have any impact on the sign or significance of other coefficients. In particular, regulatory agency remains negatively associated with labor efficiency.

As suggested by Dal Bó and Rossi (2007), corruption may divert managerial effort away from the productive process, and the way for firms to meet their service obligations is to use more inputs. Additionally, a regulatory agency might have a different impact according to the country's level of corruption. Thus, in Column (6) we include country-level corruption and its interaction with regulatory agency as additional controls. In this specification the coefficient of corruption is negative and significant, indicating that more corruption in the country is associated with more labor-inefficient firms, while the coefficient on the interaction is not significant. Again, regulatory agency remains strongly associated with lower labor requirements.

Even after controlling for corruption, a concern is that there may be other country characteristics that are correlated with both labor-efficiency and the presence of a regulatory agency. To address this concern we control for a number of observed

country-level time-varying characteristics, such as GDP per capita, population density, and quality of the bureaucracy. The coefficients on these country-level controls are individually and jointly not significant. The sign, magnitude, and significance of the coefficients of interest remain unaltered.[3]

As pointed out by Heckman et al. (1997), an important source of bias in the difference-in difference approach could arise when treated and control firms are not compared at common values of matching variables. We deal with this potential problem of comparing the incomparable by applying the difference-in-differences approach to the support common to treated firms and control firms (defined as the sub-sample obtained by deleting all observations of control firms with an estimated propensity score lower than the minimum one of the treated group and all observations of treated firms with an estimated propensity score higher than the maximum one of the control group). We estimate the propensity score from a Probit model of the probability of the introduction of a regulatory agency at some point during the sample window as a function of a set of average pre-treatment characteristics, such as GDP per capita, quality of the bureaucracy, IMF agreement, and electricity losses. All explanatory variables in the estimated Probit model (not reported) are statistically significant, and the balancing property is satisfied. In alternative specifications we tried including other firm-level characteristics, such as labor productivity and service coverage, but they were not significant. As shown in Table 5, results corresponding to the difference-in-differences approach applied to the common support are consistent with previous results.

To further validate our results we perform additional estimations under a wide range of alternative specifications and samples. The value and significance of the

[3] Results mentioned but not reported are available from the authors upon request.

coefficients of interest remain unchanged when we drop one firm at the time or one country at the time, when we estimate a Cobb-Douglas instead of a translog labor requirement function, and when the variables are included in levels rather than in logs. Conclusions in terms of the significance of the coefficients remain also unchanged when standard errors are clustered at country-year combinations.

Other measures of firm performance and social welfare

Table 6 reports estimates of the impact of regulatory agencies on three measures of firm efficiency (labor per connection, operating expenditures per connection, and electricity losses) and three measures of social welfare (service coverage, frequency of interruptions, and average residential tariffs).

Labor per connection is a weaker measure of labor efficiency than the one obtained from the labor requirement model, but it has the advantage of allowing us to increase the number of firms and countries in the sample compared to the labor requirement specification. Difference-in-differences estimates for the labor per connection specification confirms the labor requirement results: regulatory agencies have a positive impact on labor productivity and private firms outperform public ones in terms of labor productivity. As in the labor requirement case, the impact from private participation is more important than the impact from the presence of regulatory agencies. Again, there are no effects arising from the interaction between regulatory agencies and ownership.

We then consider operating expenditures as a performance indicator. Using operating expenses has the advantage of including expenditures for work contracted outside the firm, thus making the measure of variable inputs more comparable between firms with different levels of horizontal integration. Results for operating expenditures per connection suggest that regulatory agencies have a positive impact

on firm efficiency, in the sense that they incur in lower operating expenditures. Again, there is no differential impact of regulatory agencies according to ownership type.

Our third measure of firm efficiency is the electricity that is lost in the distribution process. As shown in Column (3) of Table 6, the coefficients for ownership and regulatory agency are not significant in the equation for the electricity that is lost for technical and non-technical reasons. Energy losses, however, tend to be lower for private firms operating under the control of a regulatory agency.

So far, the partial performance indicators have focused on the supply side of the business. From the point of view of users, other dimensions are much more important. We have information of three such dimensions: quality of service, access to the service as measured by the coverage rate, and average residential tariff (that gives a sense of the affordability of the service provided).

Column (4) reports results for quality of service, as measured by the frequency of interruption of the electricity service. The presence of a regulatory agency is strongly associated with a decrease in the frequency of interruption, and this association is similar for private and public firms. The coefficient on the private dummy variable is not significant in this specification.

As reported in Column (5), there is a positive association between regulatory agencies and service coverage. Furthermore, the positive and significant coefficient of the interaction variable indicates that regulatory agencies have a stronger impact on service coverage for private firms.

Finally, estimates from the model in Column (6) indicates that being a private firm operating under a regulatory agency is negatively associated to average residential tariffs. These results suggest that residential customers have benefited, through lower tariffs, from the significant improvements in labor productivity

associated to privatization. Interestingly, regulatory agencies have a positive impact on public-firms average tariffs, a result that is likely to reflect improvements in cost recovery efforts and tariff rebalancing associated with the typical mandate assigned to independent regulators.

In Table 7 we apply the difference-in-differences approach to the sample restricted to the common support. Again, results corresponding to the difference-in-differences in common support are consistent with previous results.

Overall, our empirical analysis suggests that the establishment of regulatory agencies in developing and transition countries is associated with higher social welfare. Again, to validate our results we perform a number of robustness checks. First, the sign, magnitude, and significance of the coefficients of interest remain mostly unchanged when we drop one firm at the time or one country at the time. Second, results remain unaltered when we include country-level controls such as GDP per capita. Finally, conclusions in terms of the significance of the coefficients remain also unaltered when standard errors are clustered at country-year combinations.

5. Conclusions

We have presented what we believe is the first attempt at using firm-level data to evaluate the impact of introducing a regulatory agency on firm performance and social welfare. Our analysis focuses on the electricity distribution sector in developing and transition countries, and it includes three measures of firm performance (labor productivity, operation expenditures per connection, and electricity losses) and three measures of social welfare (service coverage, frequency of interruptions, and residential tariffs).

The overall picture emerging from our empirical analysis is that the introduction of regulatory agencies in developing and transition countries is associated with more efficient firms and with higher social welfare.

Our empirical results indicate that regulatory agencies are strongly associated with higher labor efficiency at the firm level in the sense that less labor is used to produce a given level of output. We also find that private firms are substantially more efficient in their use of labor than state-owned firms. The estimated effects are large in economic terms. The association we identify between regulatory agencies and firm efficiency is robust. To deal with problems of omitted variable bias we controlled for time effects, firm effects, and a set of time-varying firm-level and country-level regressors. The association between regulatory agencies and labor efficiency remains significant in the presence of all of these variables. This is interesting because it suggests that the presence of a regulatory agency plays a separate role that is distinct from the impact of private sector participation and from an unstable or insecure environment. The effect of regulatory agencies remains significant when taking into account the problem of energy theft.

In order to check our focus on labor efficiency, we estimate an alternative productivity model using operating expenditures instead of the number of employees. Again, we find regulatory agencies to be associated with higher firm efficiency. We also explore the impact of regulatory agencies on the electricity that is lost due to technical and non-technical reasons. We find that private firms operating under the control of a regulatory agency have lower energy losses.

Aside from firm efficiency we also explore the impact of regulatory agencies on social welfare. First, regulatory agencies are strongly associated to a decrease in the frequency of interruptions. Second, regulatory agencies have a positive impact on

coverage rates, and this impact is stronger for private firms. Finally, we find a positive impact of regulatory agencies on welfare through lower tariffs, although the impact in this case is restricted to private firms.

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Table 1. Summary statistics

	Mean	*Standard deviation*	*Sample size*
Firm-level variables:			
Electricity sold (MWh)	66829600	450549307	2644
Connections	726930	1688384	2583
Residential connections	616798	1431352	2362
Distribution network (Km)	22561	68274	1288
Employees	2947	6855	2253
OPEX per connection	255	413	515
Proportion of energy lost	0.16	0.08	2324
Interruption frequency rate	5380	14971	158
Coverage	0.79	0.21	1634
Average residential tariff	107	184	1713
Private participation	0.29	0.46	2814
Regulatory agency	0.52	0.50	2899
Country-level variables:			
Corruption	2.90	0.79	2759
Quality of the Bureaucracy	2.10	0.76	2759
GDP per capita	2960	2050	2899
Debt stock	19174574899	38757151326	1161
IMF agreement	0.44	0.50	1222
Population density	51.10	71.71	2899

Table 2. Distribution of firms according to ownership and regulation status

	With regulatory agency	*Without regulatory agency*
With private participation	109 (in 24 countries)	1
Without private participation	84 (in 26 countries)	19 (in 13 countries)

Note: There are seven firms operating in three countries with undefined ownership status.

Table 3. Time schedule of the establishment of regulatory agencies and the introduction of private participation in electricity distribution

Year	Countries introducing a regulatory agency	Countries introducing private participation
Before 1992		Bolivia (Santa Cruz); Ivory Coast; Brazil (Pará, São Paulo, Minas Gerais, and Tocantins)
1992	Argentina (Buenos Aires)	Belize
1993	Argentina (San Luis and Tucumán)	Argentina (Buenos Aires and San Luis); Philippines
1994		Mali
1995	Argentina (Catamarca and Santiago del Estero); Bolivia; Colombia; Nicaragua; South Africa	Argentina (Formosa, La Rioja, and Santiago del Estero); Peru (Lima)
1996	Argentina (Entre Ríos, Formosa, La Rioja, Río Negro, Salta, and San Juan); Mexico; Zambia	Argentina (Catamarca, Entre Ríos, Tucumán, and San Juan); Bolivia (Cochabamba, La Paz, and Oruro); Brazil (Espírito Santo, Paraná, and São Paulo); Peru (Lima)
1997	Argentina (Jujuy and Mendoza); Brazil (Maranhão, Rio de Janeiro, Santa Catarina, Sergipe, and Tocantins); Costa Rica; Ecuador; El Salvador; Georgia; Guatemala; Panamá; Peru	Argentina (Jujuy, Río Negro, and Salta); Brazil (Rio de Janeiro and São Paulo); Colombia (Valle del Cauca); Czech Republic (Prague); Peru (Lima and Southern Peru)
1998	Armenia; Brazil (Ceará, Pará, Rio Grande do Sul, and São Paulo); Ethiopia; Ghana; Moldova; Poland; Uruguay	Brazil (Bahia, Ceará, Mato Grosso, Pará, Rio Grande do Norte, Rio Grande do Sul, São Paulo, and Sergipe); Colombia (Cundinamarca)
1999	Belize; Brazil (Bahia); Ivory Coast; Estonia; India (Andhra Pradesh and Haryana); Kenya; Senegal	Argentina (Mendoza); Brazil (Pará, Paraíba, and São Paulo); Colombia (Cundinamarca); El Salvador; Guatemala (Escuintla, Guatemala, and Sacatepéquez); Panama; Peru (Central Peru and Northern Peru)
2000	Argentina (Córdoba); Brazil (Amazonas, Goiás, Mato Grosso, and Rio Grande do Norte); Cameroon; India (Delhi); Mali; Niger; Uganda	Brazil (Espírito Santo, Maranhão, Paraná, Pernambuco, Rio Grande do Sul, and Sergipe); Czech Republic (Jihomoravský); Georgia; Guatemala (Eastern Guatemala and Western Guatemala); Senegal
2001	Brazil (Pernambuco); Malawi; Namibia; Tanzania	Brazil (Paraíba); Cape Verde; Moldova; Nicaragua
2002	Brazil (Alagoas, Mato Grosso do Sul, and Paraíba); Czech Republic; Malaysia; Mauritania; Philippines; Slovak Republic	Brazil (Rio Grande do Sul); Cameroon
2003	Brazil (Acre); Cape Verde	Azerbaijan; Slovak Republic (Central Slovakia and Western Slovakia); Tanzania
2004	Russia	Czech Republic (Jihočeský); Poland; Russia; Slovak Republic (Eastern Slovakia)
2005	Brazil (Espírito Santo); Central African Republic	
2006	Azerbaijan	

Note: Argentina, Brazil, and India have regional regulators.

Table 4. Estimates of labor requirements

Variable	Dependent variable: number of employees, in logs					
	(1)	(2)	(3)	(4)	(5)	(6)
Regulatory agency	-0.096	-0.092	-0.076	-0.066	-0.121	-0.175
	[.024]***	[.027]***	[.027]***	[.030]**	[.033]***	[.065]***
	(0.037)***	(0.040)**	(0.042)*	(0.048)	(0.053)**	(0.076)**
Private			-0.126	-0.088	-0.117	-0.122
			[.032]**	[.037]**	[.040]***	[.043]***
			(0.061)**	(0.068)	(0.075)	(0.087)
Regulatory agency x Private				-0.053	0.029	0.021
				[.038]	[.042]	[.043]
				(0.062)	(0.070)	(0.075)
Ln (Sales)	0.269		0.263	0.261	0.245	0.234
	[.071]***		[.070]***	[.070]***	[.074]***	[.074]***
	(0.140)*		(0.136)*	(0.137)*	(0.124)**	(0.123)*
Ln (Sales + Network losses)		0.306				
		[.078]***				
		(0.149)**				
Ln (Connections)	0.506	0.545	0.498	0.498	0.548	0.600
	[.102]***	[.108]***	[.107]***	[.107]***	[.112]***	[.111]***
	(0.205)**	(0.218)***	(0.222)**	(0.224)**	(0.208)***	(0.203)***
Ln (Distribution network)	0.042	0.009	0.041	0.042	0.018	0.002
	[.068]	[.070]	[.069]	[.069]	[.068]	[.060]
	(0.138)	(0.140)	(-0.076)	(0.141)	(0.137)	(0.112)
Ln (Proportion of residential connections)					-0.040	-0.035
					[.436]	[.416]
					(0.637)	(0.616)
Ln (Corruption)						-0.033
						[.017]*
						(0.020)*
Ln (Corruption) x Regulatory agency						0.030
						[.020]
						(0.024)
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Firm dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of countries	36	35	36	36	32	30
Number of firms	174	171	168	168	155	153
Observations	1097	979	1044	1044	933	908
R-squared	0.99	0.99	0.99	0.99	0.99	0.99

Notes: Huber-White robust standard errors are shown in brackets. Standard errors clustered at the firm level are shown in parentheses. In all cases we are estimating a translog form. To save space, second order terms are not shown. *Significant at the 10% level; **Significant at the 5% level; ***Significant at the 1% level.

Table 5. Estimates of labor requirements in common support

Variable	Dependent variable: number of employees, in logs					
	(1)	(2)	(3)	(4)	(5)	(6)
Regulatory agency	-0.119	-0.103	-0.093	-0.079	-0.139	-0.167
	[0.026]***	[0.028]***	[0.030]***	[0.034]**	[0.038]***	[0.068]**
	(0.037)***	(0.037)***	(0.042)**	(0.050)	(0.056)**	(0.075)**
Private			-0.153	-0.114	-0.133	-0.136
			[0.041]***	[0.041]***	[0.043]***	[0.046]***
			(0.079)*	(0.077)	(0.083)	(0.095)
Regulatory agency x Private				-0.062	0.034	0.019
				[0.044]	[0.046]	[0.048]
				(0.068)	(0.073)	(0.077)
Ln (Sales)	0.354		0.379	0.381	0.367	0.346
	[0.087]***		[0.087]***	[0.086]***	[0.091]***	[0.095]***
	(0.176)**		(0.170)**	(0.169)**	(0.156)**	(0.168)**
Ln (Sales + Network losses)		0.404				
		[0.089]***				
		(0.179)**				
Ln (Connections)	0.436	0.471	0.404	0.399	0.439	0.496
	[0.111]***	[0.114]***	[0.115]***	[0.115]***	[0.120]***	[0.121]***
	(0.214)**	(0.219)**	(0.229)*	(0.230)*	(0.212)**	(0.219)**
Ln (Distribution network)	0.036	0.003	0.036	0.037	0.020	-0.006
	[0.073]	[0.073]	[0.075]	[0.076]	[0.074]	[0.066]
	(0.149)	(0.146)	(0.152)	(0.154)	(0.149)	(0.123)
Ln (Proportion of residential connections)					-0.052	-0.044
					[0.574]	[0.551]
					(0.871)	(0.846)
Ln (Corruption)						-0.021
						[0.020]
						(0.020)
Ln (Corruption) x Regulatory agency						0.024
						[0.022]
						(0.025)
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Firm dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of countries	31	31	31	31	27	27
Number of firms	134	133	128	128	123	123
Observations	880	825	827	827	756	738
R-squared	0.99	0.99	0.99	0.99	0.99	0.99

Notes: Huber-White robust standard errors are shown in brackets. Standard errors clustered at the firm level are shown in parentheses. In all cases we are estimating a translog form. To save space, second order terms are not shown. *Significant at the 10% level; **Significant at the 5% level; ***Significant at the 1% level.

Table 6. Estimates for firm efficiency and social welfare

	Firm efficiency			Social welfare		
	Labor/ Connections	OPEX/ Connections	Electricity losses	Frequency of interruptions	Coverage	Residential tariff
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Regulatory agency	-0.067	-0.274	0.038	-0.541	0.021	0.225
	[0.022]***	[0.094]***	[0.022]*	[0.182]***	[0.009]**	[0.037]***
	(0.036)*	(0.177)	(0.033)	(0.219)**	(0.018)	(0.058)***
Private	-0.256	0.535	-0.062	0.177	-0.010	0.112
	[0.041]***	[0.164]***	[0.028]**	[0.125]	[0.011]	[0.029]***
	(0.073)***	(0.267)*	(0.044)	(0.152)	(0.017)	(0.041)***
Regulatory agency x	-0.057	-0.142	-0.138	-0.411	0.047	-0.299
Private	[0.040]	[0.151]	[0.029]***	[0.403]	[0.013]***	[0.043]***
	(0.072)	(0.234)	(0.046)***	(0.527)	(0.026)*	(0.072)***
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Firm dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of countries	49	27	48	16	30	39
Number of firms	209	62	207	25	162	180
Observations	2092	475	2255	145	1579	1669
R-squared	0.94	0.98	0.82	0.98	0.96	0.99

Notes: Huber-White robust standard errors are shown in brackets. Standard errors clustered at the firm level are shown in parentheses. *Significant at the 10% level; **Significant at the 5% level; ***Significant at the 1% level.

Table 7. Estimates for firm efficiency and social welfare in common support

	Firm efficiency			Social welfare		
	Labor/ Connections	OPEX/ Connections	Electricity losses	Frequency of interruptions	Coverage	Residential tariff
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Regulatory agency	-0.073	-0.372	0.0004	-0.534	0.028	0.235
	[0.023]***	[0.102]***	[0.021]	[0.181]***	[0.011]***	[0.041]***
	(0.037)**	(0.194)*	(0.031)	(0.223)**	(0.024)	(0.062)***
Private	-0.266	0.610	-0.078	0.182	-0.003	0.087
	[0.042]***	[0.173]***	[0.028]***	[0.126]	[0.013]	[0.037]**
	(0.076)***	(0.302)**	(0.045)*	(0.157)	(0.021)	(0.051)*
Regulatory agency x	-0.043	0.044	-0.139	-0.410	0.059	-0.329
Private	[0.041]	[0.145]	[0.029]***	[0.400]	[0.016]***	[0.049]***
	(0.074)	(0.213)	(0.047)***	(0.529)	(0.034)*	(0.083)***
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Firm dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of countries	37	22	37	12	24	29
Number of firms	153	51	154	18	126	129
Observations	1684	416	1893	132	1229	1265
R-squared	0.94	0.97	0.82	0.98	0.97	0.98

Notes: Huber-White robust standard errors are shown in brackets. Standard errors clustered at the firm level are shown in parentheses. *Significant at the 10% level; **Significant at the 5% level; ***Significant at the 1% level.