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Institutions and Performance of Regulated Firms: Evidence from Electric Utilities in the Indian States

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Keywords: Quality of state institutions; electricity distribution in India; heteroscedastic stochastic frontier models; inefficiency determinants.

JEL Classification D22, L51, L94, O43

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EPRG WORKING PAPER

Institutions and Performance of Regulated Firms: Evidence from Electric Utilities in the Indian States

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1. Introduction

There is ample evidence in the literature and it is commonly accepted that the quality of institutions have a significant influence on the economic development of countries (see Easterly and Levine, 2003; Acemoglu et al., 2002). But, can we also trace the effect of institutional endowment down to the level of specific sectors and regions of countries? There is, however, scarce knowledge and empirical evidence of such effects at the micro-level. In this paper we set out to examine the possible effect of state-level institutional quality and economic development on the performance of electricity distribution utilities in India.

The reform trend in the electricity sector began in the 1990s and spread to many countries around the world. This concurred with new developments in regulatory economics aimed at improving the efficiency of network industries (see Shleifer, 1985; Laffont and Tirole, 1993; Littlechild, 1983). In general, generation and retailing of electricity is potentially competitive while transmission and distribution networks are natural monopolies. The importance of the regulation of the networks has frequently been highlighted because of their impact on social welfare (e.g., Joskow, 2014). A significant issue in the regulation of network utilities is to provide them with incentives to improve efficiency (Jamasb and Pollitt, 2007).

Incentive-based regulation has become the dominant mode to replacing alternatives such as cost-of-service regulation.[1] Some regulation models are based on the utilities' performance evaluation measured through benchmarking methods. The identification of best-performing (or 'frontier') firms allows measuring the relative efficiency of the firms in the sector. The main objective of the sector regulator is to protect the interests of consumers and ensure that they benefit from the efficiency gains in the competitive as well as the regulated segments (Jamasb and Pollitt, 2007).

Since the 1990s, India has implemented a number of reform steps to improve the efficiency of the electricity sector. However, significant performance differences seem to persist among the utilities across the country. This is evidenced by various empirical studies that use Data Envelopment Analysis (DEA) to measure the efficiency of electricity distribution utilities in India or in specific states (Bobde and Tanaka, 2018; Yadav et al., 2013, 2011, 2010; Saxena and Thakur, 2011; Meenakumari et al., 2009; and Thakur et al., 2006. It is possible that the observed disparity in the efficiency of the utilities is partly the result of the differences in the institutional endowment of the different states.

[1] Cost-of-service regulation is based on firms' actual costs. Shleifer (1985) indicates that under this regulation model, economic welfare may drop well below the optimum level.

The “Electricity Act, 2003” (with amendments in 2004, 2007 and 2008) and now called as Electricity (Amendment) Act, 2014, and downstream policies have led to some important changes in the sector in the last decade by initiating corporatisation, unbundling, competition, accountability and private sector participation (Shukla and Thampy, 2011). In addition, corruption remains a longstanding pressing issue in the Indian electricity sector and it can be directly related to the lack of transparency and poor institutional endowment (Thakur et al., 2004). The enactment of the “Electricity Act, 2003” was expected to address these issues.

Electricity sector policy in India have also other objectives that include improving electrification, reducing network energy losses, and managing cross subsidies. However, these objectives have also yielded inefficiencies in the sector (Thakur et al., 2006). India started its electricity sector reform from 1991 by allowing the entrance of Independent Power Producers (IPPs) (Sharma et al., 2005) with mixed success to attract the much needed investments in the sector. In addition, of the 1.4 billion of the world population who lack access to electricity, India accounts for over 300 million of them (IEA, 2015).

In this paper we analyse the effects of state-level institutional endowment on cost efficiency of electricity distribution utilities in respective states of India from 2006-07 to 2011-2012. Electricity distribution networks are very suitable for studying efficiency effects of institutions as they are generally modular systems and are rather similar in main aspects of their design. We estimate a set of Stochastic Frontier Analysis (SFA) models to evaluate the influence of institutional endowments of states on the performance of the sector. In addition, we examine the effect of economic factors such as GDP and its growth rate on the performance of the network utilities. In India, there is a strong policy focus on achieving social objectives and, in particular, on electrification. However, this has also led to large and persistent network energy losses and inefficiencies in the sector. We also examine the role of network energy losses which is costly for the sector and environmental quality.

This remainder of this paper is organised as follows. Section 2 briefly summarises the literature on the effect of institutions on economic performance and focuses on the case of India and particularly on the electricity sector. In Section 3 we introduce the methodological approach and the stochastic frontier models that are estimated. Section 4 presents the data and variables employed in the analysis and reports the estimates and the post estimation analysis of these, which includes a simulation of potential cost savings per state from incremental enhancements in institutional quality. Section 5 is conclusions.

2. Electricity Distribution and State Institutions in India

In many developing countries, a combination of ineffective state institutions, market imperfections and poor infrastructure hinder the effectiveness of economic and social policies. One of the affected sectors is the electricity industry, where poor performance is a cause of poor economic development (Di Bella and Grigoli, 2016; Balza et al., 2013). Barriers to expanding access to electricity are financial and economic; capacity and technical; and policy and institutional (Sovacool, 2012; Watson et al., 2012; Nepal and Jamasb, 2012). Dramani and Tewari (2014) examine the institutions and electricity sector performance in Ghana and find that institutions positively influence the reserve margin and installed capacity and have the potential to increase the reliability and efficiency of distribution utilities.

Electricity is a concurrent subject in India, with multiple jurisdictions – i.e. centre, state and at Panchayat level).[2] A key reform step has been the unbundling of the sector into its four main constituent functions, namely generation, transmission, distribution and retailing of electricity.[3] The expansion of the transmission system has been carried out based on detailed technical studies and is rather planned. However, the distribution system has grown in an unplanned and haphazard manner making it incapable of meeting the objective of fulfilling the growing demands of consumers on an urgent basis.[4] The unplanned development of distribution sector, over time, has created an inefficient distribution system.

Indian electricity distribution caters to nearly 200 million consumers having a connected load of about 400 GW. The consumers are served by around 73 distribution utilities (MoP, 2016).[5] Despite the reforms, in the form of corporatisation and unbundling, the distribution sector is having large financial losses making the sector unsustainable (Shunglu Committee, 2011). Bhattacharya and Patel (2008) discuss the systemic flaws and sector vulnerabilities of the sector and suggest a commercial orientation of the utilities, improving revenues and cash flow, and deep sectorial reforms based on competition and private ownership.

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[2] The Panchayati Raj system in India was formalised in 1992 for more decentralised administration, as a system of governance in which gram panchayats are the basic units of local administration. The system has three levels: Gram Panchayat (village-level), Mandal Parishad or Block Samiti or Panchayat Samiti (block-level), and Zila Parishad (district-level).

[3] Many reforming countries, mainly in developing countries, have not separated the retail function from the distribution function for some or all types of consumers.

[4] Under an ambitious central scheme, the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), access to electricity, measured in terms of electrified villages, rose from 59% in 2000 to almost 95% at the end of 2013 (CEA, 2014). Note that access figures differ with alternative measures. For instance, when using the percentage of households with access the number falls to 74% in 2010 (Banerjee et al., 2014).

[5] 73 distribution utilities consisting of 13 electricity departments, 17 private distribution companies, 41 corporatised distribution companies and 2 State Electricity Boards (SEBs).

Consequently, the electricity distribution in India is characterised by inefficiency, low productivity, frequent interruption in supply and poor voltage, among other features, and all this despite the restructured Accelerated Power Development and Reforms Programme (APDRP) and the Restructured Accelerated Power Development and Reforms Programme (R-APDRP) funding.[6] India's reform policies have not been able to achieve reliable, efficient power because distribution reforms have not been carried out (Bag et al., 2014). In order, to overcome the difficulties leading to technical and governance challenges, a radical restructuring of the sector has been prescribed (Tankha et al., 2010). As a result, the Ministry of Power (MoP), Government of India, has been taking reform initiatives including unbundling,[7] corporatisation, privatisation and outsourcing of various services of the distribution sector.

With the enactment of the Electricity Regulatory Act (ERC Act 1998), state and central regulators were introduced as independent, autonomous institutions in the sector. At centre level, Central Electricity Regulatory Commission (CERC) was formed, which lays down the major guidelines and has jurisdiction over both centrally-owned utilities and inter-state transmission and trade issues. In addition, each federal state was mandated to have its own regulatory authority known as State Electricity Regulatory Commissions (SERCs) with regulatory oversight at the state-level. With the federal structure, India regulators have freedom and flexibility to implement reforms. The regulators have impacted the sector by introducing own tariffs, dispute resolution and increasing confidence to reform process. State regulators decide tariff based on cost plus regulation, incentive regulation is not followed by any regulators, but its provision exists in the "Electricity Act, 2003".

The oversight role of the state regulators is crucial for the functioning of the sector the quality of which is an important aspect of institutional quality and performance of the utilities (Erdogdu, 2013). Ghosh and Kathuria (2016) addressed the impact of institutional quality typified as regulatory governance on the performance of thermal generation plants in India, but no study is reported for the distribution sector. Thus, it is important to explore the links between quality of institutions and performance of the Indian distribution utilities regardless of ownership. The paper finds that institutional endowment is essential for the performance of the electricity sector.

[6] R-APDRP started in 2008 is a revised version of the APDRP. The APDRP scheme was initiated in 2002-03 assistance from the centre to the states to reduce the average technical and commercial losses and improve the quality and reliability of service. This was to be achieved by strengthening and upgrading the sub-transmission and distribution system of high-density load centres. R-APDRP is for urban areas, i.e., towns and cities with a population more than 30,000 people (10,000 people in special category states). The focus of R-APDRP is on actual, demonstrable performance, and achieving sustained reduction in energy losses.

[7] Presently, most states have unbundled their erstwhile SEBs and have corporatised the successor entities having one generation and transmission company and many distribution companies according to the requirement of the states. Some Indian states like Tamil Nadu and Punjab unbundled their SEBs into two entities; one dedicated to transmission and another for both generation and distribution.

We represent the institutional framework through a set of variables that can be considered proxies for institutional quality and state intervention, and have an effect on electricity distribution firms' cost efficiency. The model captures the effect of institutions on transaction costs that ultimately should affect the viability and profitability of the economic activity (North, 1990).

3. Methodology

In this section we introduce the theoretical cost function used to estimate and analyse the performance of the electricity distribution firms in our sample. The estimation approach will allow us to obtain important features such as cost elasticities or marginal costs that permit to study economic characteristics of the technology in the sector. In general terms, a total cost function can be described as follows:

$$C = f(y, w, x, \beta) \tag{1}$$

where C represents total firms' costs, y is a set of outputs that often includes delivered energy and customers, w are the prices of the inputs labour and capital, x are other control variables and β are the parameters to be estimated.

Starting from Aigner et al. (1977) (ALS henceforth) and Meeusen and van den Broeck (1977) the SFA literature has been developed based on the idea that deviations with respect to cost (or alternatively production) functions, such as in equation (1), should be attributed to inefficiency in firms' management and to random shocks. The authors proposed econometric models that include two random terms that simultaneously measure controlled and uncontrolled differences with respect to a frontier. This methodology allows obtaining a best-practice frontier that can be used to identify benchmarks in firms' performance. According to this approach, and after taking logarithms,[8] equation (1) can be written as in (2):

$$\ln C_{it} = \ln f(y_{it}, w_{it}, x_{it}, \beta) + v_{it} + u_{it} \tag{2}$$

where i stands for the firm and t for time, v is a standard noise term that follows a normal distribution and u is a one-sided error term that captures firms' cost inefficiency. An interesting issue that it is worth to analyse is the likely existence of factors that may affect the performance of the companies.

[8] The equation is presented in a linear form through taking logarithms of the variables included in the model. This strategy makes easier the interpretation of the β-parameters estimated as they can be directly interpreted as elasticities.

A shortcoming of the models proposed by Aigner et al. (1977) and Meeusen and van den Broeck (1977) is that this circumstance is not taken into account. It is important then to note that if this matter is not properly addressed it can yield biased estimates of the parameters of the model and the efficiency scores due to heteroscedasticity issues (Caudill and Ford, 1993). This question is frequently encountered in the SFA literature and some studies have explored strategies to address this matter. There are several frontier approaches, namely parametric, nonparametric and semi-parametric (or semi-nonparametric) that can be applied in utility benchmarking to measure firms' performance. Each approach has pros and cons, thus the choice of a specific approach is arguable and may influence the results and policy implications derived. Coelli et al. (2005) propose estimating alternative models in order to assess the robustness and appropriateness of the results obtained for a given selected approach.

The (parametric) SFA models that can be applied to estimate the determinants of firms' inefficiency can be divided in three categories depending on how these contextual variables (also called environmental or z-variables) are included in the model. These z-variables can be introduced through the pre-truncation mean, the pre-truncation variance or in both places of the inefficiency term of the model. It should be noted that the selection of an appropriate functional form and model suitable to deal for the assessment of efficiency determinants in SFA is ultimately an empirical issue.

Llorca et al. (2016) summarise the models that can be applied with different frontier approaches to address the presence of environmental factors that may affect the performance of firms. The study estimates several models proposed in the SFA literature to analyse the influence of environmental variables (mainly weather conditions) on the performance of transmission networks in the US. Several studies include environmental factors to evaluate performance of transmission and distribution utilities (e.g., Yu et al., 2009; Growitsch et al., 2012; Kuosmanen, 2012; Orea et al., 2015). However, these studies are focused on firm-specific factors that affect individual performance and not on the general context of the sector or the country. We are interested in the effect of institutions on the performance of distribution firms through analysing the performance of utilities in different states.

In this paper we follow the model of Reifschneider and Stevenson (1991), Caudill and Ford (1993) and Caudill et al. (1995) (RSCFG henceforth), which satisfies the so-called scaling property. The specific characteristic of the models that fulfil this property is that changes in the environmental variables affect the scale but not the shape of the inefficiency term (Álvarez et al., 2006). This implies that the inefficiency term can be decomposed in a multiplicative way as follows:

$$u_{it}(z_{it}, \delta) = h(z_{it}, \delta)u_{it}^{*} \quad (3)$$

where $h(z_{it}, \delta)$ is a scaling function that is always positive, z_{it} denotes environmental variables introduced in the model, δ is a set of parameters to be estimated and u^*_{it} is a measure of "raw" inefficiency that does not depend on z_{it}. This property facilitates the interpretation of the effect of the environmental variables on mean efficiency, as δ does not depend on the distribution of inefficiency (Wang and Schmidt, 2002). In particular, in the RSCFG model, u_{it} follows a half-normal distribution (like in the ALS model) and the scaling function presents an exponential functional form. Therefore, the standard deviation of the inefficiency term in that model can be expressed as:

$$\sigma_{it} = \sigma_u \exp(z'_{it}\delta) \tag{4}$$

As a consequence, the estimates of δ are simply the derivatives of the logarithm of the inefficiency with respect to the z-variables. Considering the same particular conditions for the inefficiency term and the scaling function assumed by Caudill et al. (1995), the stylised cost function to be estimated can be presented in the following form:

$$\ln C_{it} = \ln f(y_{it}, w_{it}, x_{it}, \beta) + v_{it} + \exp(z'_{it}\delta)\, u^*_{it} \tag{5}$$

4. Data and Results

This section presents the data, the econometric specification of the model and the results.[9] We have a balanced panel data that contains information on 52 electricity distribution utilities, which operate in 24 Indian states.[10] The sample period goes from 2006-2007 to 2011-2012. The relatively short period of time should not be an issue here, since the main source of institutional differences in our sample comes from the comparison between states (between-units variation) and not over time (within-units variation).

Table 1 presents the descriptive statistics of the variables that we include in our analysis.[11] Table 2 shows the correlation coefficients of the variables. The correlations among the technical variables are relatively large (higher than 60%). This is commonplace in the efficiency studies of the electricity transmission and distribution networks. On the other hand, the correlations among other variables and, in particular, among the institutional variables, which will be introduced as efficiency determinants in the model, are much smaller, nearly always smaller than 50%.

[9] All the models presented in this paper are estimated by maximum likelihood.

[10] The states included in this analysis are: Andhra Pradesh, Assam, Bihar, Chhattisgarh, Delhi, Goa, Gujarat, Haryana, Himachal Pradesh, Jammu and Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Odisha, Punjab, Rajasthan, Tamil Nadu, Tripura, Uttar Pradesh, Uttarakhand and West Bengal.

[11] For a detailed definition and sources of the variables, see the Appendix.

Table 1: Summary statistics for data on electricity distribution firms in India

Variable	*Unit*	*Mean*	*Std. Dev.*	*Min.*	*Max.*
Total Distribution Cost (D_COST)	Crore rupees (2011)	1,388	1,993	123	22,506
Energy Sold (ENE)	MU's	10,370	11,725	395	80,132
Customers (CUS)	Number of people	3,261,180	3,866,851	230,580	23,180,000
Energy Losses (LOS)	MU's	4,166	4,474	163	33,785
Distribution Capacity (DCA)	MVA	7,895	8,206	492	62,194
Labour Price (LPR)	Crore rupees (2011)	0.04	0.02	0.01	0.14
Capital Price (KPR)	Index	117.68	4.80	110.12	125.08
Private Utility (PRIV)	Dummy	0.19	0.39	0	1
Average Technical and Commercial Losses (AT&C)	%	29.69	14.48	6.12	83.68
Gross Domestic Product (GDP)	Crore rupees (2011)	336,369	227,767	11,759	1,112,220
Growth of GDP (GRW)	%	8.51	4.44	-5.98	22.47
Human Development Index (HDI)	Index in 2008	0.50	0.11	0.36	0.79
President's Rule (PRESI)	Number of times	0.04	0.21	0	1
Coalition Government (COALI)	Number of times	0.08	0.35	0	2
Surfaced Road Length to Total Road Length (ROAD)	%	64.10	21.03	11.55	93.55
Share of Public Expenditure in GDP (EXP)	%	6.06	2.07	1.31	16.55
Share of Secondary Sector in GDP (SESEC)	%	29.87	7.59	10.67	48.16

Note: MU's stands for million units. 1 MU is equivalent to 1,000 megawatt hours (MWh). MVA represents megavolt-amperes, a measure of apparent power.

Table 2: Correlation matrix of variables

	D_COST	*ENE*	*CUS*	*LOS*	*DCA*	*LPR*	*KPR*	*PRIV*	*AT&C*	*GDP*	*GRW*	*HDI*	*PRESI*	*COALI*	*ROAD*	*EXP*	*SESEC*
D_COST	1	0.731	0.732	0.481	0.575	0.130	0.113	-0.163	-0.153	0.215	0.076	0.131	-0.085	-0.062	0.200	-0.300	-0.069
ENE	0.731	1	0.930	0.687	0.881	0.038	0.113	-0.207	-0.236	0.427	-0.012	0.159	-0.089	-0.071	0.315	-0.358	-0.013
CUS	0.732	0.930	1	0.602	0.816	0.052	0.085	-0.240	-0.243	0.405	-0.026	0.192	-0.041	-0.051	0.195	-0.332	-0.091
LOS	0.481	0.687	0.602	1	0.684	0.139	0.047	-0.258	0.386	0.253	0.008	-0.138	-0.071	0.014	0.155	-0.103	-0.046
DCA	0.575	0.881	0.816	0.684	1	0.094	0.130	-0.225	-0.149	0.425	0.004	0.113	-0.099	-0.113	0.253	-0.274	-0.137
LPR	0.130	0.038	0.052	0.139	0.094	1	0.273	0.038	0.207	-0.140	-0.035	0.063	-0.005	-0.024	-0.050	0.092	-0.221
KPR	0.113	0.113	0.085	0.047	0.130	0.273	1	0.000	-0.100	0.170	-0.342	0.000	-0.061	-0.148	0.127	0.089	-0.072
PRIV	-0.163	-0.207	-0.240	-0.258	-0.225	0.038	0.000	1	-0.036	-0.084	0.023	0.137	-0.106	-0.107	-0.343	-0.269	-0.143
AT&C	-0.153	-0.236	-0.243	0.386	-0.149	0.207	-0.100	-0.036	1	-0.348	-0.006	-0.475	0.069	0.125	-0.362	0.424	-0.077
GDP	0.215	0.427	0.405	0.253	0.425	-0.140	0.170	-0.084	-0.348	1	-0.070	-0.059	-0.061	-0.086	0.422	-0.393	-0.069
GRW	0.076	-0.012	-0.026	0.008	0.004	-0.035	-0.342	0.023	-0.006	-0.070	1	-0.036	-0.066	0.039	0.008	-0.110	0.057
HDI	0.131	0.159	0.192	-0.138	0.113	0.063	0.000	0.137	-0.475	-0.059	-0.036	1	0.010	-0.065	0.330	-0.202	-0.245
PRESI	-0.085	-0.089	-0.041	-0.071	-0.099	-0.005	-0.061	-0.106	0.069	-0.061	-0.066	0.010	1	0.528	-0.037	0.146	0.066
COALI	-0.062	-0.071	-0.051	0.014	-0.113	-0.024	-0.148	-0.107	0.125	-0.086	0.039	-0.065	0.528	1	-0.032	0.090	0.149
ROAD	0.200	0.315	0.195	0.155	0.253	-0.050	0.127	-0.343	-0.362	0.422	0.008	0.330	-0.037	-0.032	1	-0.092	0.168
EXP	-0.300	-0.358	-0.332	-0.103	-0.274	0.092	0.089	-0.269	0.424	-0.393	-0.110	-0.202	0.146	0.090	-0.092	1	-0.023
SESEC	-0.069	-0.013	-0.091	-0.046	-0.137	-0.221	-0.072	-0.143	-0.077	-0.069	0.057	-0.245	0.066	0.149	0.168	-0.023	1

Equation (6) presents the econometric specification of the model that we estimate. The cost frontier is defined using a transcendental logarithmic (translog) cost function, which can be considered a second-order approximation to the firms' underlying cost function. Therefore, our cost function can be expressed as:

$$\ln\left(\frac{D\_COST_{it}}{KPR_{it}}\right) = \alpha + \sum_{p=1}^{4}\beta_p \ln y_{pit} + \beta_L \ln\left(\frac{LPR_{it}}{KPR_t}\right) + \beta_t t$$

$$+\sum_{p=1}^{4}\sum_{q=1}^{4}\beta_{pq}\ln y_{pit}\ln y_{qit} + \frac{1}{2}\beta_{LL}\left[\ln\left(\frac{LPR_{it}}{KPR_t}\right)\right]^2 + \frac{1}{2}\beta_{tt}t^2$$

$$+\sum_{p=1}^{4}\beta_{pL}\ln y_{pit}\ln\left(\frac{LPR_{it}}{KPR_t}\right) + \sum_{p=1}^{4}\beta_{tp}t\ln y_{pit} + \beta_{tL}t\ln\left(\frac{LPR_{it}}{KPR_t}\right)$$

$$+\beta_{PRIV}PRIV_i + v_{it} + \exp\left(\sum_{r=1}^{10}\delta_r z_{rit}\right)u_{it}^{*} \qquad (6)$$

where α is the intercept of the cost frontier, y stands for our four outputs and z includes nine efficiency determinants and a time trend.

The dependent variable in the model is the total annual cost of each utility (D_COST), often labelled as Totex (Total Expenditure). This variable aggregates the Opex (Operational Expenditure), which includes operations and maintenance, labour as well as other expenditures; and Capex (Capital Expenditure), which incorporates the depreciation of capital assets and total interest cost. The four outputs we consider are: Energy Sold (ENE), Number of Customers (CUS), Network Energy Losses (LOS) and Distribution Capacity (DCA).[13] This set of variables can be defined as standard in the efficiency and productivity literature and benchmarking models used by sector regulators in incentive regulation of utilities (see Jamasb and Pollitt, 2001). Labour Price (LPR) is measured at firm-level and it is calculated using information about employees' expenditure. This variable and the total cost are normalised using the Capital Price (KPR) in equation (6) to impose homogeneity of degree one in prices.[14] We include a time trend (t) to measure technical change and it interacts with the other variables in the translog cost function, which allows reflecting non-neutral technical change. A dummy that identifies the Private Firms (PRIV) is also used.

Regarding the efficiency determinants, we introduce another time trend and 9 variables that may affect the firms' performance. One of these variables is firm-specific, Average Technical and Commercial Losses (AT&C), while the remaining variables are measured at state-level. Energy losses can be seen as an institutional outcome that can be partially

[13] Energy Losses is introduced as an 'undesirable' output and it is expected to have an incremental effect on firms' costs. We considered to include network length as an output, but this variable was not a significant cost driver in our model. Nevertheless, Distribution Capacity can be understood as a proxy of the size of the network.

[14] Capital price is difficult to measure. We opt for a Wholesale Price Index (WPI) similar to Llorca et al. (2016) who use a Produce Price Index (PPI) in the case of US electricity transmission industry.

determined by the quality of the institutions at state-level (Kochhar et al., 2006; Subramanian, 2007).[15] This variable is included because it mainly represents the theft and non-payment of electricity, which is one of the main issues in the Indian electricity distribution sector (Thakur et al., 2006). The GDP of the state, the growth of state GDP and the state Human Development index (HDI) have also been included as determinants of firms' performance in the model.

The last five variables have been introduced considering the study by Dash and Raja (2009). These authors empirically analyse the effect of institutions and quality of governance on economic growth and development in Indian states. They use as explanatory factors several variables and indices that can be grouped in three blocks: institutional indicators, extent and quality of state intervention and political environment of Indian states. We use a set of those variables that are relevant for the electricity distribution sector: (i) the number of times the President's rule was imposed (PRESI); (ii) the number of times the Chief Minister headed the Coalition Government (COALI), reflecting both variables the political environment and stability of the state; (iii) the ratio of surfaced road length to total road length (ROAD), which is related to the condition of the state as provider of infrastructure and necessary goods and services; and (iv) the state public expenditure expressed as a percentage of state the GDP (EXP), reflecting the extent of the intervention of the state government in the economy. Additionally, we introduce the share of the secondary sector in the state GDP (SESEC) as a control variable in order to account for the level of industrialisation of the state.

Table 3 presents the parameter estimates of three models.[16] The first of them is a model in which the functional form of the cost frontier is a Cobb-Douglas. This ALS model does not incorporate efficiency determinants. As expected from a cost function, we observe that all the outputs coefficients are positive and statistically significant. If we summed up these cost elasticities of outputs we obtain 0.839, which represents the inverse of the elasticity of scale (Hanoch, 1975). This value evidences the existence of economies of scale in the Indian electricity distribution industry. The coefficient of the labour price is significant and positive, as it is also expected.

The coefficient of the time trend is significant and negative, indicating the existence of technical change (i.e., total cost declines over time). The dummy of private ownership is significant and positive, indicating that private firms exhibit higher total costs. This result is not new; Bobde and Tanaka (2018) have found efficiency advantages of public electricity distribution utilities in India. Moreover, it is frequently asserted that

[15] Dash and Raja (2009) consider transmission and distribution losses as a proxy for rule of law and they use it as an institutional indicator in their analysis.

[16] The subscript s in some of the variables introduced in the inefficiency term indicates that the variable is measured at state-level.

efficiency in the electricity sector depends more on the type of regulation than ownership (see Newbery, 1995; and for the case of India, Sen and Jamasb, 2012).

In the second model in Table 3, we use a translog specification for the cost frontier, but we do not incorporate efficiency determinants. The results seem to be robust as all the first-order coefficients remain significant and with the expected sign, and most of the interactions between variables are also significant. The Likelihood Ratio (LR) test presented at the bottom of the table shows a value of 76.245 for the first model, which indicates that the Cobb-Douglas is rejected against the translog specification. Therefore, this is the specification that we will be using for estimating the RSCFG model that incorporates efficiency determinants. In addition, if we compare the RSCFG against the ALS model, both of them with a translog specification, we observe that the latter is rejected, so we can assume that the former is the one that best fits our data and hence it is our preferred model.[17]

In the RSCFG model we observe similar results to those from both ALS models. The parameter estimates show the same signs than in the previous models and are in the same order of magnitude. Nevertheless, the incorporation of efficiency determinants seems to have reduced the statistical significance of some of the interactions between variables in the cost frontier. On the other hand, most of the variables in the efficiency term are significant and show the expected sign. The first of the variables, Average Technical and Commercial Losses, AT&C, shows a negative coefficient. This means that this variable has a negative effect on firms' inefficiency.

In conjunction with the result that we obtain for the variable energy losses in the frontier, we can state that there is an ambiguous relationship between network energy losses and firms' costs. On the one hand, energy losses increase network costs as larger energy losses imply more intensive use of the network. It can be assumed that this involves higher maintenance and operation costs, i.e., Opex. On the other hand, energy losses increase firms' efficiency, which results in lower costs. These larger efficiencies may arise from reductions in capital costs and investments (Capex) that make the capital appear to be more efficiently used.

[17] Other SFA models that allow the introduction of efficiency determinants through alternative ways were estimated: through the pre-truncation mean (Battese and Coelli, 1995) and both through the pre-truncation mean and variance (Wang, 2002) of the inefficiency term. These models were discarded, the first one is rejected against the RSCFG model based on the Vuong (1989) test for non-nested models and the second one due to lack of convergence.

Table 3: Parameters estimates of the models

	ALS (Cobb-Douglas)			ALS (translog)			RSCFG (translog)		
Variable	***Est.***		***Est./s.e.***	***Est.***		***Est./s.e.***	***Est.***		***Est./s.e.***
Frontier									
Intercept	1.359	***	51.72	1.361	***	27.82	1.402	***	21.72
$\ln ENE_{it}$	0.343	***	4.73	0.295	***	4.15	0.220	*	1.93
$\ln CUS_{it}$	0.265	***	4.26	0.188	***	2.75	0.199	**	2.23
$\ln LOS_{it}$	0.090	***	2.64	0.105	***	3.13	0.135	**	1.97
$\ln DCA_{it}$	0.142	**	2.28	0.214	***	3.78	0.228	**	2.50
$\ln (LPR_{it}/KPR_{it})$	0.318	***	4.97	0.317	***	4.81	0.290	***	2.96
t	-0.048	***	-3.75	-0.035	***	-2.86	-0.058	***	-2.78
$½ (\ln ENE_{it})^2$				0.019		0.06	-0.114		-0.26
$½ (\ln CUS_{it})^2$				0.108		0.45	0.075		0.29
$½ (\ln LOS_{it})^2$				-0.011		-0.14	0.012		0.10
$½ (\ln DCA_{it})^2$				0.747	***	3.56	0.644	**	2.10
$½ [\ln (LPR_{it}/KPR_{it})]^2$				0.221		1.26	0.141		0.46
$½ t^2$				-0.031	*	-1.88	-0.034		-1.55
$\ln ENE_{it} \cdot \ln CUS_{it}$				0.380	*	1.76	0.441		1.63
$\ln ENE_{it} \cdot \ln LOS_{it}$				0.217	**	1.98	0.175		0.94
$\ln ENE_{it} \cdot \ln DCA_{it}$				-0.463	**	-2.40	-0.414		-1.64
$\ln ENE_{it} \cdot \ln (LPR_{it}/KPR_{it})$				0.333	*	1.65	0.301		0.97
$\ln ENE_{it} \cdot t$				-0.028		-0.74	-0.048		-0.71
$\ln CUS_{it} \cdot \ln LOS_{it}$				0.052		0.61	0.064		0.48
$\ln CUS_{it} \cdot \ln DCA_{it}$				-0.433	**	-2.54	-0.405	*	-1.81
$\ln CUS_{it} \cdot \ln (LPR_{it}/KPR_{it})$				0.342	*	1.84	0.391		1.55
$\ln CUS_{it} \cdot t$				-0.085	**	-2.50	-0.073		-1.41
$\ln LOS_{it} \cdot \ln DCA_{it}$				-0.082		-1.00	-0.063		-0.53
$\ln LOS_{it} \cdot \ln (LPR_{it}/KPR_{it})$				0.113		1.25	0.138		0.86
$\ln LOS_{it} \cdot t$				-0.049	**	-2.40	-0.044		-1.46
$\ln DCA_{it} \cdot \ln (LPR_{it}/KPR_{it})$				-0.622	***	-4.72	-0.680	***	-3.43
$\ln DCA_{it} \cdot t$				0.111	***	3.64	0.116	**	2.34
$\ln (LPR_{it}/KPR_{it}) \cdot t$				0.036		1.07	0.011		0.20
$PRIV_i$	0.229	***	3.38	0.219	***	2.81	0.216	**	2.42
Noise term									
$\ln (\sigma_v^2)$	-3.586	***	-12.73	-4.066	***	-13.53	-4.140	***	-12.69
Inefficiency term (variance)									
Intercept	-0.571	***	-5.22	-0.757	***	-7.32	-1.022	***	-8.69
$AT\&C_{it}$							-0.031	*	-1.92
$\ln GDP_{st}$							-0.711	***	-4.27
GRW_{st}							0.069	***	3.14
HDI_s							-2.844	**	-2.21
$PRESI_{st}$							-0.542		-0.84
$COALI_{st}$							0.768	**	2.02
$ROAD_{st}$							0.011	*	1.81
EXP_{st}							-0.178	***	-2.86
$SESEC_{st}$							-0.054	***	-3.36
t							0.303	***	3.71
Number of observations	312			312			312		
Log-likelihood	-192.774			-154.652			-127.656		
Chi-squared LR test	76.245 ***			53.991 ***			-		
	(21)			(10)			-		

Notes: Significance code: *p<0.1, **p<0.05, ***p<0.01
The unrestricted model in model selection LR tests is the one immediate to the right. Degrees of freedom in parentheses.

If we pay attention to the variables measured at state-level, we find quite reasonable results. GDP has a negative effect on inefficiency, while the growth of this variable increases inefficiency. This latter result, which can be seen by some readers as counterintuitive, may be related to an issue of adjustments costs. It is not unreasonable to assume that large (and perhaps unexpected) growths or decreases in GDP of Indian states could be related to a more difficult decision-making process and larger inefficiencies in the management of electric utilities.[18] A similar result is found by Llorca et al. (2016), who observe that a positive growth in electricity demand has a negative effect on the efficiency of the US electricity transmission utilities. They attribute this finding to the anticipation of investments (that are expected to be efficiently used in the future, but not at present) to meet future demand. HDI which is a composite index of health, education and income (for more details see the Appendix) exhibits a negative and significant effect on cost inefficiency that may reflect a positive influence of the quality of the manpower over firms' management.

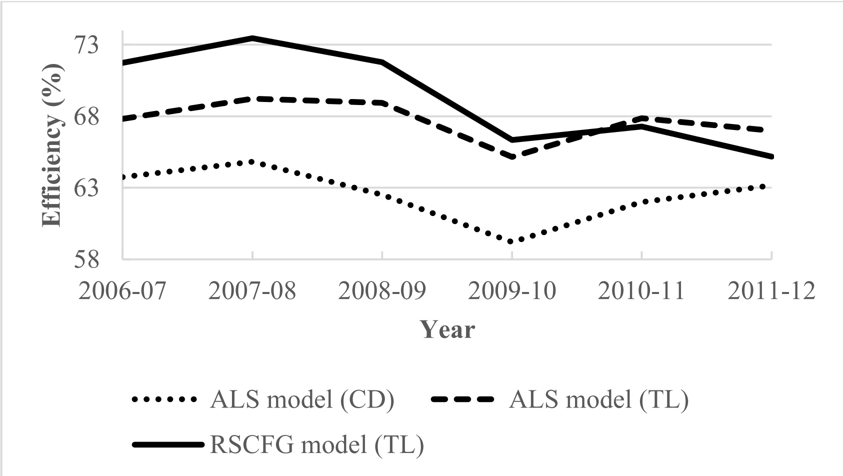
Regarding the variables that are more directly related to the quality of institutions and governance, we observe that PRESI is not statistically significant. Nevertheless, COALI is positive and significant. Although a coalition government reduces the dominance of individual parties, it may not necessarily be a stable government. Some decisions on relevant matters could take longer to be made and hence it is expected that "instability of policy at higher levels of administration promotes inefficiency" (Adelman and Morris, 1971, p.77). This circumstance seems to hinder the efficient management of the utilities in our sample. The coefficient of ROAD is slightly significant and positive, suggesting that the percentage of surfaced road in the state increases inefficiency of the utilities. This result might reflect a trade-off between the spending on transport infrastructure and the electricity sector, or a crowding out effect triggered by state public investment resulting in a poorer management of the utilities. On the contrary, the variable EXP shows a negative and highly significant coefficient. This could be seen as rather counterintuitive because a higher ratio of public expenditure over GDP indicates a stronger state intervention in the economy and this could leave room for more corruption and rent-seeking activities (Dash and Raja, 2009). However, this does not hold in our sample and it seems that higher public expenditure has a positive effect on the performance of the distribution utilities. In addition, the coefficient of the control variable, SESEC, is significant and indicates that a higher level of industrialisation in the state implies lower inefficiencies in the sector.

Finally, the time trend is positive, indicating an increase of the inefficiency over time, as can be observed in Figure 1. It should be noted that the three estimated models present similar patters but different efficiency levels. The RSCFG, our preferred model, shows a

[18] Some authors like Bhide et al. (2005) argue that state GDP growth can be used as proxy for quality of institutions assuming that those states with higher growth are those with better institutions. However, this assumption may not necessarily hold (Dash and Raja, 2009).

decline in the average performance of the distribution utilities that has been uneven along the analysed period. In the initial year, the average efficiency score of the utilities was 71.7%. It augmented the year after, just before starting to decrease until reaching 65.2% in the final year of the sample.

Figure 1: Average efficiency score over time



The mean efficiency for the whole period was 69.3% which is similar to those by Thakur et al. (2006) for 26 state owned electric utilities for 2001-2002.[19] The found an average total efficiency of 68% using a CCR (Charnes et al., 1978) formulation, while the average technical efficiency when they use a BCC (Banker et al., 1984) formulation is 84%. Moreover, they find larger inefficiencies for larger utilities which also coincide with the results that we obtain from our models. This is evidenced by a correlation of -14.4% between the cost efficiencies and the energy sold in our sample.

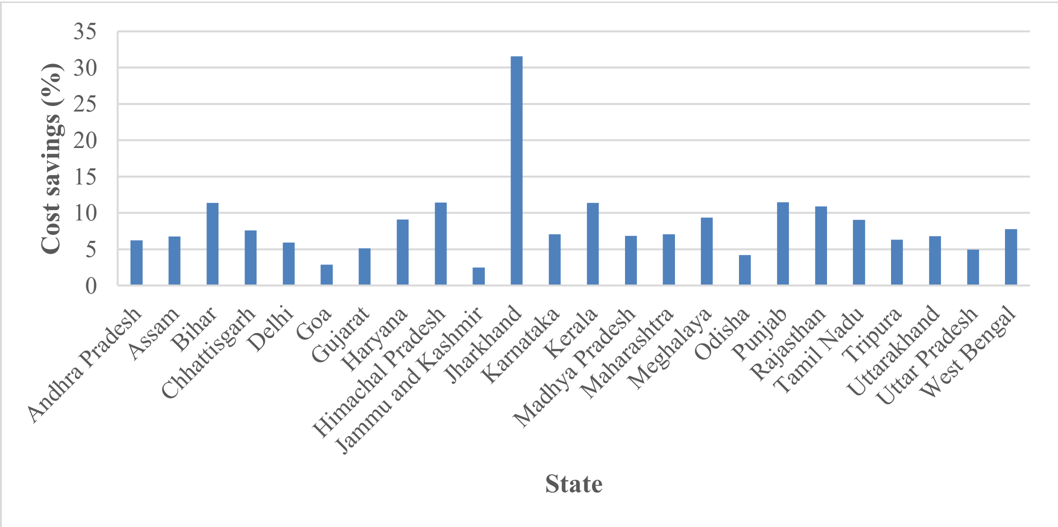
Post estimation analysis of results

In order to gain a better understanding of the influence of institutions on the performance of the electricity sector, we carried out a simulation. Figure 2 shows the potential cost savings per state produced by an improvement in the quality of institutions in our sample. The blue bars represent the percentage of savings with respect to total cost that could be made by electricity distribution companies in each

[19] In addition to differences related to the sample and period, it must be said that the model utilised by Thakur et al. (2006) is DEA, which is a nonparametric approach and different from the parametric approach employed here. As it has been suggested in Section 3, the use of alternative approaches can produce very different results. Therefore, we provide the information here as a mere reference.

state for the period from 2006-07 to 2011-12 if there would be a marginal improvement in our proxies for the quality of institutions each year.[20] The average value of the cost savings for the whole sample represents 8.73%, although substantial differences can be observed between states. For example, for Goa and Jammu and Kashmir the size of the potential savings is lower than 5%, while for Jharkhand reaches a value of 31.57%. The savings for the overall sample and the whole period analysed amount to a total of 37,788 Crore rupees (2011) (approximately 8 billion 2011 USD), ranging the savings per state between 28 (Goa) and 5,446 Crore rupees (2011) (Rajasthan).

Figure 2: Cost savings related to an enhancement of institutions



It is noteworthy that there are two features that make these computations be considered a lower bound for potential savings in the whole country. First, it is expected that improvements in the quality of institutions have in turn a wider effect on the economy that will be ultimately reflected in indicators such as the GDP or the HDI of the states over time. According to the parameters estimated and presented in Table 3, this 'indirect effect' can only boost the savings presented here and reinforces the importance of the quality of institutions on sectorial performance. Second, our sample does not cover all the utilities that service all 29 states and 7 union territories of the country.

[20] We simulate a marginal improvement in the quality of institutions as a simultaneous reduction of one unit in COALI (i.e., the number of times the Chief Minister headed the Coalition Government) along with an increase of 1% in EXP (i.e., the share of state public expenditure in state GDP). They should reflect a concurrent increase in political stability and governmental participation in the economy of each state. We do not consider PRESI and ROAD in simulations, the former due to lack of significance of its coefficient and the latter due to difficulties to fully justify its effect. It should be mentioned that the results of simulation do not change significantly when marginal improvements in ROAD are incorporated.

A chronic issue in the electricity distribution in India is the high level of network energy losses (Thakur et al., 2006). It could be argued that the magnitude of energy losses is interlinked with quality of institutions and regulation. In order to explore this issue we use the estimated elasticities to compute the marginal cost of the losses at observation-level. Figure 3 shows two scatter plots of the marginal costs of energy losses versus the energy losses by the electric utilities. In Figure 3a the computed marginal costs only consider the estimated coefficients related to the variable LOS in the cost frontier. In Figure 3b it is additionally considered the effect of energy losses via the inefficiency term, i.e., through the variable AT&C.[21] Both figures show a clear positive relationship indicating that as energy losses increases, the marginal cost of losses increases as well.[22] This relationship is also observed when these marginal costs are compared with the other outputs in the model. However, the most relevant matter when comparing these figures is the large number of observations that exhibit a negative marginal cost when the overall effect of energy losses on costs is considered, i.e., the effect through inefficiency is also incorporated in the computation.

Figure 3: Marginal cost of energy losses

Figure 3a: Frontier

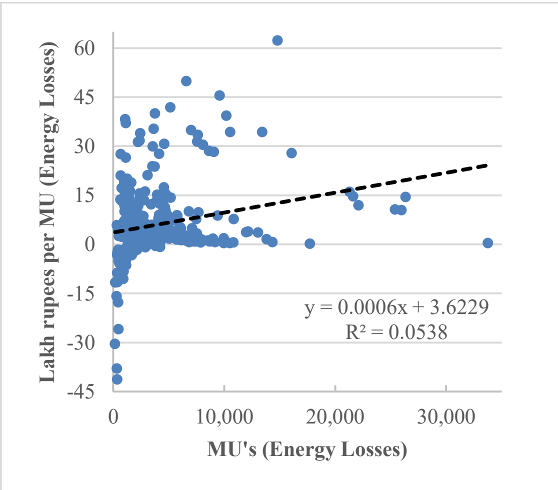
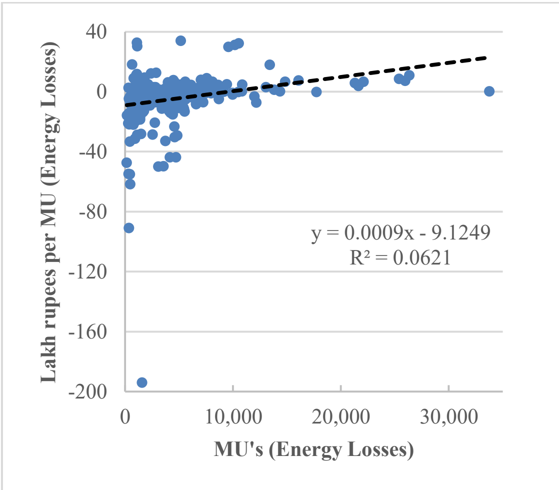


Figure 3b: Frontier + Inefficiency term



[21] Taking into account that AT&C=100·LOS/(ENE+LOS), the 'overall' marginal cost of energy losses can be computed as:

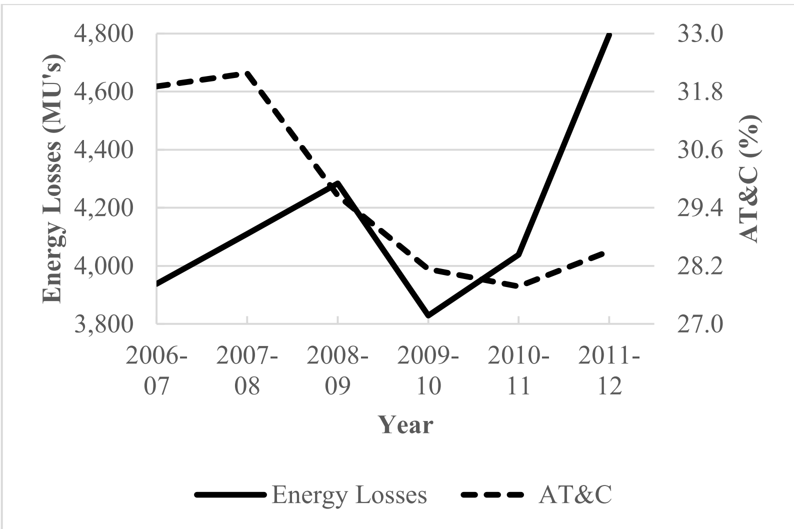
$$MC_{LOS} = \frac{\partial \ln C}{\partial \ln LOS}\frac{C}{LOS} = \left[\frac{\partial \ln f(y,w,x,\beta)}{\partial \ln LOS} + \frac{AT\&C(100-AT\&C)}{100}\frac{\partial h(z,\delta)}{\partial AT\&C}u^*\right]\frac{C}{LOS}$$

[22] Most of the observation-specific marginal costs that we obtain are in a reasonable order of magnitude. However, in cases that are far from sample mean (e.g., those which are largely negative), the estimates should be viewed with caution. The non-satisfaction of the regularity conditions imposed by economic theory is a fairly common issue when more flexible functional forms are used (Barnett et al., 1995).

As shown in Figure 3a, average marginal cost is 6.16, which indicates that (on average) a rise of one additional MU in energy losses is translated into an increase of 6.16 lakh rupees (2011) per MU (approximately 13.21 2011 USD per MWh) in total costs for the utilities. However, as previously mentioned, this result seems to contrast with the negative coefficient observed for the variable AT&C in the inefficiency term of our RSCFG model in Table 3. This coefficient indicates that as energy losses increase firms enhance their cost efficiency. We observe that the average marginal cost in Figure 3b is -5.18 lakh rupees (2011) per MU (approximately -11.12 2011 USD per MWh). This shows that utilities can reduce costs by limiting their energy loss reducing efforts. This makes sense when low prices make loss reduction activities uneconomic and/or when the cost of losses is passed to consumers. The figure also shows that for companies with small energy losses, which tend to be those in which also the number of customers and electricity delivered is lower, there may be incentives (e.g., not investing in improving their network as it increases their Capex) to increasing instead of reducing energy losses. This may be a consequence of a lack of regulatory incentives.

Figure 4 presents the evolution of energy losses and AT&C over time for the average of our sample. Focusing on AT&C, we observe that there has been a reduction from almost 32% to 28.5%. This is in line with the results that we observed in Table 3 and Figure 1, increases (decreases) in AT&C improve (worsen) the cost efficiency of the utilities and the average efficiency has declined over time. Bringing together these results, we can infer that the average cost efficiency in our sample has decreased due to the efforts by the utilities to reduce their actual AT&C as in Figure 4.

Figure 4: Evolution of Energy Losses and AT&C over time



Nevertheless, the magnitude of energy losses during the same period has increased from about 4,000 to 4,800 MU's. This indicates that the electricity injected in the system has grown at a higher pace than the reduction in the AT&C. This is a significant issue, because, as discussed earlier, some companies can have incentives to limit their energy loss reducing activities in the current regulatory regime in India. Finally, we highlight the importance of institutions along with the regulators to keep the efforts to reduce the still high levels of energy losses in India.

5. Conclusions

Since the 1990s, India has taken steps to reform its electricity sector as in many other countries around the world. The aim is to improve the efficiency of the sector and attract private capital. The mandate of the sector regulator is to oversee the functioning of the competitive and regulated segments of the sector and to ensure that consumers benefit from the achieved efficiency gains. In India, the enactment of the "Electricity Act, 2003" had this objective.

At the same time, there is ample literature that suggests that institutional endowment affects economic development of countries. Can we also trace the effect of institutional endowment to specific sectors and regions of a country? There is scarce empirical evidence on the effect of region-level institutions on the performance of firms. India is a suitable case to explore this link at firm- and state-level. The quality of institutions varies across the different Indian states and the absence of transparency and unproductive institutions often manifest itself in the form of corruption that in turn leads to economic inefficiency.

We use a novel dataset and stochastic frontier techniques to analyse the cost efficiency of the Indian electricity distribution utilities in different states while determining the effect of quality of institutions on their efficiency. The findings show that energy losses increase the cost of networks as larger energy losses imply more intensive use of the network leading to higher maintenance and operation costs. We also find that firms with higher losses have higher efficiency which results in lower costs. The higher efficiencies may arise from underspending in loss reducing investments. Taking into account both effects, we obtain an average marginal cost of -5.18 lakh rupees per additional MU in energy losses, which indicates that the companies do not have sufficiently strong incentives to reduce their energy losses. Overall, we find an average cost efficiency of 69.3% and a declining efficiency over the period analysed.

In addition, the results show that institutional and some other contextual factors such as Human Development Index, the country political context and the level of economic development have a significant effect on firm performance. This paper adds to the empirical evidence on the effect of institutional endowment but in a rare micro-level study. Energy regulators need to take into account the high- and lower-level institutional factors when comparing efficiency of utilities and setting the financial incentives for improving their performance.

The results obtained in this paper show that economic incentives alone are not sufficient for improving the efficiency of regulated firms and institutions constrain the ability of firms to realise their technical potential. Therefore, measures to improve the quality of institutions and in particular that of the state regulatory agencies can also be worthwhile investments with long-term rewards.

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Appendix

Table A.1: Data - Variables, definitions and sources

Variable	Data Source	Definition
Total Distribution Cost (D_COST)	1. PFC (Power Finance Corporation). 2010. The Performance of State Power Utilities for the Years 2006-07 to 2008-09. New Delhi. 2. PFC (Power Finance Corporation). 2011. The Performance of State Power Utilities for the Years 2007-08 to 2009-10. New Delhi. 3. PFC (Power Finance Corporation). 2012. The Performance of State Power Utilities for the Years 2008-09 to 2010-11. New Delhi. 4. PFC (Power Finance Corporation). 2015. The Performance of State Power Utilities for the Years 2011-12 to 2013-14. New Delhi.	• Cost incurred in distributing the electricity to end consumers. It is calculated as: *Totex – (Power Purchased Cost + Generation Cost)* • Totex is made up of the following components: *Power Purchased Cost + Generation Cost + Employee Cost + O&M Cost + Total Interest Cost + Depreciation + Admin. & Gen. Expenditure + Other Expenditure*
Energy Sold (ENE)	1. PFC (Power Finance Corporation). 2010. The Performance of State Power Utilities for the Years 2006-07 to 2008-09. New Delhi. 2. PFC (Power Finance Corporation). 2011. The Performance of State Power Utilities for the Years 2007-08 to 2009-10. New Delhi. 3. PFC (Power Finance Corporation). 2012. The Performance of State Power Utilities for the Years 2008-09 to 2010-11. New Delhi. 4. PFC (Power Finance Corporation). 2015. The Performance of State Power Utilities for the Years 2011-12 to 2013-14. New Delhi.	• Total energy delivered to the end consumers in MU's.
Customers (CUS)	1. Annual Reports of the corresponding / individual distribution utilities published yearly. 2. Annual Revenue Requirement and Tariff Petition filed by	• Number of end consumers served.

	the distribution utilities to their respective State Electricity Regulatory Commission.	
Energy Losses (LOS)	1. PFC (Power Finance Corporation). 2010. The Performance of State Power Utilities for the Years 2006-07 to 2008-09. New Delhi. 2. PFC (Power Finance Corporation). 2011. The Performance of State Power Utilities for the Years 2007-08 to 2009-10. New Delhi. 3. PFC (Power Finance Corporation). 2012. The Performance of State Power Utilities for the Years 2008-09 to 2010-11. New Delhi. 4. PFC (Power Finance Corporation). 2015. The Performance of State Power Utilities for the Years 2011-12 to 2013-14. New Delhi.	• It is calculated as: *Net Energy Input – Energy Realised*
Distribution Capacity (DCA)	1. Annual Reports of the corresponding / individual distribution utilities published yearly. 2. Annual Revenue Requirement and Tariff Petition filed by the distribution utilities to their respective State Electricity Regulatory Commission. 3. http://www.cag.gov.in/	• Distribution Transformer Capacity in MVA.
Labour Price (LPR)	1. PFC (Power Finance Corporation). 2010. The Performance of State Power Utilities for the Years 2006-07 to 2008-09. New Delhi. 2. PFC (Power Finance Corporation). 2011. The Performance of State Power Utilities for the Years 2007-08 to 2009-10. New Delhi. 3. PFC (Power Finance Corporation). 2012. The Performance of State Power Utilities for the Years 2008-09 to 2010-11. New Delhi. 4. PFC (Power Finance Corporation). 2015. The Performance of State Power Utilities for the Years 2011-12 to 2013-14. New Delhi. 4. Annual Revenue Requirement and Tariff Petition filed by	• It is calculated as: *Employees Expenditure / Number of Employees*

	the distribution utilities to their respective State Electricity Regulatory Commission. 5. http://www.cag.gov.in/	
Capital Price (KPR)	Office of the Economic Adviser, Government of India, Ministry of Commerce & Industry, Department of Industrial Policy &Promotion (DIPP).	• Wholesale Price Index (K, Machinery & machine tools).
Private Utility (PRIV)	http://cercind.gov.in/sebs.html	• Distribution utility that is not under the control of State government.
Average Technical and Commercial Losses (AT&C)	1. PFC (Power Finance Corporation). 2010. The Performance of State Power Utilities for the Years 2006-07 to 2008-09. New Delhi. 2. PFC (Power Finance Corporation). 2011. The Performance of State Power Utilities for the Years 2007-08 to 2009-10. New Delhi. 3. PFC (Power Finance Corporation). 2012. The Performance of State Power Utilities for the Years 2008-09 to 2010-11. New Delhi. 4. PFC (Power Finance Corporation). 2015. The Performance of State Power Utilities for the Years 2011-12 to 2013-14. New Delhi.	• It is calculated as: *((Net Energy Input – Energy Realised) / (Net Energy Input)) x 100*
Gross Domestic Product (GDP)	For Sl. No. 1-32 - Directorate of Economics Statistics of respective State Governments, and for All-India - Central Statistical Organisation; Released on 1st March, 2014.	• Gross State Domestic Product (GSDP) at Current Prices (as on 31-05-2014) (Rupee in Crores).
Human Development Index (HDI)	Planning Commission (2011), *India human development report 2011: Towards social inclusion*, Government of India, New Delhi: Oxford University Press.	• It is a composite index of outcome indicators that comprises three dimensions: life expectancy, acquisition of education and knowledge, and the standard of living and command over resources (Planning Commission, 2011). It is computed as follows: *HDI = 1/3 (Health index + Education Index + Income index)*
Number of Times the	http://www.worldstatesmen.org/India_states.html	• In the Republic of India, “Article 356 provides for the

President's Rule Was Imposed (PRESI)		imposition of President's Rule in States to combat a situation 'in which the Government of the State cannot be carried on in accordance with the provisions of the constitution'" (Arora, 1990, p.1).
Number of Times the Chief Minister Headed the Coalition Government (COALI)	http://www.worldstatesmen.org/India_states.html	• "Coalition government is a combination of heterogeneous socio-political elements which are susceptible to political turmoil and storms emerging from changing socio-political conditions and compulsions" (Patil, 2001, p.587). "A coalition government always remains in pulls and pressures particularly in a multinational country like India" (Malik and Malik, 2014, p.1).
Ratio of Surfaced Road Length to Total Road Length (ROAD)	Infrastructure Statistics - 2014 (Third issue, VOL. II) published by Central Statistics Office Ministry of Statistics and Programme Implementation Government of India, New Delhi. www.mospi.nic.in	• A surfaced road is considered "a road with a hard smooth surface of bitumen or tar" (Taral, 2015, p.2).
Ratio of State Public Expenditure as a Percentage of Total State Gross Domestic Product (EXP)	India, State Finances: A Study of State Budgets (Mumbai, Reserve Bank of India, 2011-12).	• "Measures the degree of Government intervention in various economic activities. A higher ratio indicates more State intervention in the economy and there is a greater scope for corruption and other kinds of rent-seeking activities. Hence, unnecessary State interventions preclude productive activities and encroach upon the freedom of private individuals, subsequently creating stumbling blocks for economic prosperity" (Dash and Raja, 2009, p.9).
Percentage Share of Secondary Sector in State Gross Domestic Product Growth (SESEC)	Central Statistical Organisation (CSO) and Ministry of Industry, Government of India, 2013.	• Percentage contribution of Industry Sector in GSDP Growth. This variable essentially reflects the level of industrialisation of the state.