THE EFFECT OF INSTITUTIONS ON SECTORAL PERFORMANCE: THE CASE OF ELECTRICITY DISTRIBUTION IN INDIAN STATES

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Overview

Since the 1990s, India has adopted a number of measures to reform its electricity sector as in many countries around the world (Jamasb et al., 2017). The main objective of electricity reforms is to provide utilities with incentives to enhance their efficiency both in terms of operation and investment. The aim of the sector regulator is to ensure that consumers benefit from the achieved efficiency gains. In India, the enactment of the "Electricity Act, 2003" was aimed at improving the efficiency of the sector. Improving the efficiency of the electricity distribution utilities through incentive-based regulation mechanisms is a central component of most electricity sector reform.

At the same time, it is generally accepted that the quality of institutions affects the economic performance of developed as well as developing countries (see, e.g, Acemoglu *et al*., 2002). India is a good example in case where the quality of institutions vary across the different states and the absence of transparency and unproductiove institutions often manifests itself in the from of corruption leading to economic inefficiency (Thakur *et al*., 2004). However, there is scarce empirical evidence in the literature of the effect of quality of institutions issue on the performance of the electricity distribution sector. In order to fill this gap, we use a novel dataset prepared for this study and analyse the cost efficiency of the Indian electricity distribution utilities in different states while detrmining the effect of quality of institutions on their efficiency. This approach to efciency analysis can help sector regulars develop better incentive regulation schemes.

Methods

This paper uses a stochastic frontier analysis (SFA) approach to analyse the performance of 52 electricity distribution companies in different state of India India for the period 2006/7-2011/12. We estimate a set of cost functions that allow us to identify determinants of cost efficiency of the distribution networks in the different states. We extend the established methodology for measuring cost efficiency using frontier techniques to also include the effect of institutional quality in different states on the performnace of their distribution utilities. We achieve this aim by way of modelling the inefficiency term using the institutional quality variables. In general terms, a total cost function can be described as follows:

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

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.

Since Aigner *et al*. (1977) (ALS henceforth) and Meeusen and van den Broeck (1977) the SFA literature has been developed driven by the idea that deviations with respect to cost (or alternatively production) functions, like the presented in equation (1), should be attributed to inefficiency in firms' management and to random shocks. These authors proposed the estimation of 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, equation (1) can be written as:

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

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' inefficiency. An issue that it is worth to analyse is the likely existence of factors that may affect the performance of the companies. Llorca et al. (2016) present an illustrative summary of models that can be applied within different frontier approaches to address the existence of environmental factors (the so called z-variables) that may affect firms' performance. The inefficiency term can be decomposed in a multiplicative way as follows:

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

where $h(z_{it}, \delta)$ is a scaling function that is always positive, z_{it} represents the list of 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}. The standard deviation of the inefficiency term in that model can be expressed as:

$$\sigma_{uit} = \sigma_u \exp(z_{it}'\delta) \tag{4}$$

The estimates of δ are the derivatives of the logarithm of the inefficiency wrt to z-variables. Considering the same particular conditions for the inefficiency term and the scaling function assumed by Caudill *et al*. (1995), the final model to estimate is:

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

Results

Our preliminary estimates suggest that the institutional and other contextual factors such as Human Development index and political context, level of economic development have a significant effect on firms' performance. Th is evident from the significant of the variables at the endof the Table 2 (in the blue area). This is novel insight that into what theory predicts its existence but, in a rare example, we mange to show evidence of its existence in the power sector. This approach is relevance to sector regulators for developing fairer regulators incentives.

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

Variable	Unit	Mean	Std. Dev.	Min.	Max.
Total Distribution Cost	2011 Crores	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)	2011 Crores	0.04	0.02	0.01	0.14
Capital Price (KPR)	Index	117.68	4.80	110.12	125.08
Private Utility (PRIV)	-	0.19	0.39	0	1
Average Technical and Commercial Losses (ATCL)	%	29.69	14.48	6.12	83.68
Gross Domestic Product (GDP)	Rupee in 2011 Crores	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 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

Table 2. Parameters estimates of the models

	ALS (Cobb-Douglas)			ALS (translog)			CFG (translog)		
Variable	Est.		Est./s.e.	Est.		Est./s.e.	Est.		Est./s.e.
Frontier param.									
Intercept	1.359	***	51.720	1.361	***	27.820	1.402	***	21.720
$\ln ENE_{it}$	0.343	***	4.730	0.295	***	4.150	0.220	*	1.930
$\ln CUS_{it}$	0.265	***	4.260	0.188	***	2.750	0.199	**	2.230
$\ln LOS_{it}$	0.090	***	2.640	0.105	***	3.130	0.135	**	1.970
$\ln DCA_{it}$	0.142	**	2.280	0.214	***	3.780	0.228	**	2.500
$\ln (LPR_{it}/KPR_{it})$	0.318	***	4.970	0.317	***	4.810	0.290	***	2.960
t	-0.048	***	-3.750	-0.035	***	-2.860	-0.058	***	-2.780
$\frac{1}{2}(\ln ENE_{it})^2$				0.019		0.060	-0.114		-0.260
$\frac{1}{2}(\ln CUS_{it})^2$				0.108		0.450	0.075		0.290
$\frac{1}{2}(\ln LOS_{it})^2$				-0.011		-0.140	0.012		0.100
$\frac{1}{2}(\ln DCA_{it})^2$				0.747	***	3.560	0.644	**	2.100
$\frac{1}{2}[\ln (LPR_{it}/KPR_{it})]^2$				0.221		1.260	0.141		0.460
$\frac{1}{2}t^2$				-0.031	*	-1.880	-0.034		-1.550
$\ln ENE_{it} \cdot \ln CUS_{it}$				0.380	*	1.760	0.441		1.630
$\ln ENE_{it} \cdot \ln LOS_{it}$				0.217	**	1.980	0.175		0.940
$\ln ENE_{it} \cdot \ln DCA_{it}$				-0.463	**	-2.400	-0.414		-1.640
$\ln ENE_{it} \cdot \ln (LPR_{it}/KPR_{it})$				0.333	*	1.650	0.301		0.970
$\ln ENE_{it} \cdot t$				-0.028		-0.740	-0.048		-0.710
$\ln CUS_{it} \cdot \ln LOS_{it}$				0.052		0.610	0.064		0.480
$\ln CUS_{it} \cdot \ln DCA_{it}$				-0.433	**	-2.540	-0.405	*	-1.810
$\ln CUS_{it} \cdot \ln (LPR_{it}/KPR_{it})$				0.342	*	1.840	0.391		1.550
$\ln CUS_{it} \cdot t$				-0.085	**	-2.500	-0.073		-1.410
$\ln LOS_{it} \cdot \ln DCA_{it}$				-0.082		-1.000	-0.063		-0.530

ln LOS$_{it}$ · ln (LPR$_{it}$/KPR$_{it}$)				0.113		1.250	0.138		0.860
ln LOS$_{it}$ · t				-0.049	**	-2.400	-0.044		-1.460
ln DCA$_{it}$ · ln (LPR$_{it}$/KPR$_{it}$)				-0.622	***	-4.720	-0.680	***	-3.430
ln DCA$_{it}$ · t				0.111	***	3.640	0.116	**	2.340
ln (LPR$_{it}$/KPR$_{it}$) · t				0.036		1.070	0.011		0.200
PRIV$_i$	0.229	***	3.380	0.219	***	2.810	0.216	**	2.420
Compound error term									
$\lambda = \sigma_u/\sigma_v$	4.516	***	7.100	5.231	***	6.680	5.625		
$\sigma = (\sigma_v^2+\sigma_u^2)^{(1/2)}$	0.770	***	353.100	0.697	***	347.570	0.721		
Inefficiency term (variance)									
Intercept							-1.022	***	-8.690
ATCL$_{it}$							-0.031	*	-1.920
ln GDP$_{st}$							-0.711	***	-4.270
GRW$_{st}$							0.069	***	3.140
HDI$_s$							-2.844	**	-2.210
PRESI$_{st}$							-0.542		-0.840
COALI$_{st}$							0.768	**	2.020
ROAD$_{st}$							0.011	*	1.810
EXP$_{st}$							-0.178	***	-2.860
SESEC$_{st}$							-0.054	***	-3.360
t							0.303	***	3.710
Obs.		312			312			312	
Log-likelihood		-192.774			-154.652			-127.656	

Significance code: *p<0.1, **p<0.05, ***p<0.01

Conclusions

State level institutional, political, and develomental factors have a significant effect on the efficiency of the distribution networks. Energy regulators need to take into account the high-level institutional factors when comparing efficiency of network utilities and setting the financial incentives for improving their performance. The results obtained in the paper are further explored to provide policy suggestions with the aim at achieving long-term efficiency improvements.

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