Electricity Sector Reform Performance in Sub-Saharan Africa: A Parametric Distance Function Approach

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Overview

Electricity sector reforms in sub-Saharan Africa were technical, economic and structural changes with multiple and inter-related economic, social and sustainability goals. However, the strategic objective of the program was improving operational efficiency with the expectation that this will result in these goals. My thesis assesses whether the reform program has been successful in delivering its value drivers. This is to to identify and capture lessons and determine mid-course correctional strategies where necessary. This study is different, in the way it distinguishes between objectives and goals and the its explicit model of the multi-dimensionality of electricity sector reforms. It allow us to provide empirical estimates of trade-offs that are typical in such a multi-objective optimisation problem.

Method

We utilize a multi-output, multi-input output distance function to evaluate the performance of reforms for a set of 44 sub-Saharan African countries utilizing a novel and purposefully collected dataset from 2000 to 2013.The model estimated include a set of reform steps and one institutional variable as inputs and a selection of performance indicators to adequately capture the gamut of reform goals as outputs. Installed generation capacity per capita (y1),Plant load factor (y2) , the level of transmission and distribution losses (y3), consumption per capita (y4) and the level renewables in the generation mix (y5) are observed as performance indicators while a set of reform steps in dummies,i.e. the presence of an electricity law (x1), unbudling of the electricity sector (x2), the presence of an electricity regulator (x3) and private participation in the sector (x4) are observed as inputs. The 'regulatory quality' (RQ) dimensions of the World Bank Governance Indicator is used to denote the size of the electricity sector (MMW) and modelled as a determinant of inefficieny.

The general form of such a multi-input, multi-output distance function is as follows:

$$-ln(y_{Mi}) = \alpha_i + \alpha_0 + \sum_{m=1}^{M-1} \alpha_m \left(\frac{lny_{mi}}{y_{Mi}}\right) + 0.5 \sum_{m=1}^{M-1}\sum_{n=1}^{M-1} \alpha_{mn}\, ln(\frac{y_{mi}}{y_M})\, ln\left(\frac{x_{ni}}{y_{Mi}}\right) + \sum_{k=1}^{K} \beta_k\, ln(x_{ki}) + 0.5 \sum_{k=1}^{K}\sum_{l=1}^{K} \beta_{kl}\, lnx_{ki}\, lnx_{li} + 0.5 \sum_{k=1}^{K}\sum_{m=1}^{M-1} \delta_{km}\, lnx_{ki} \left(\frac{lny_{mi}}{y_M}\right) + v_{it} - u_{it}$$

Where each output is expressesd by the numeraire which is an arbitrarily selected output and dependent variable

Results

We present results of the the Battesse and Coelli (1995) model with a half- normal distribution which appears to be the most accurate specification of the electricity sector reform process. The first order coefficients of of the private participation and the presence of the regulator indices are statistically significant with the expected signs. However, the enactment of an electricity Act and unbundling of the electricity sector were statistically insignificant inputs. This suggest that these the unbundling of the electricity sector in SSA and the mere establishment of a regulator are not significant drivers of performance. Also, the RQ index is also statistically insignificant on its own but significant when interacting with the sector regulator and the private participation dummies. This reiterates our hypothesis that institutional variables exhibits characteristics of a derived variable, such that they are not effective on its own but their inherent benefits are enabled by its interaction with other active variables.

With the outputs, we find that the coefficients of the PLF and RE variables are statistically significant performance enhancing variables . However, the co-efficient of the RE indicator is negative as opposed to what expected. This however is in line with the general consensus that market-based reform models biases investment choices toward

CCGT generation typically from marginal additions by IPPs. Consequently, there is a positive relationship between performance and the percentage of renewables in the generation portfolio.

We also find an inverse relationship between the size of the electricity system and inefficiency such that as the size of the electricity sector goes up, inefficiency reduces.

The mean efficiency score was 85%, the minimum 34% and the maximum 98% with a standard deviation of 11% with a interioration of performance of a country like Ethiopia which was the best performer in the base year to the worst performer in the final year of observation. Also, it was observed that there was no direct correlation of the number of reform steps with the level of performance.

Conclusions

1. We find that that performance of the electricity sub-sector of SSA countries is explained by the model by (71%) through the reform steps introduced as inputs, performance indicators as outputs, the RQ indicator as an institutional variable, and the size of the electricity sector as denoted by the installed generation capacity (MW) as a determinant of inefficiency.

2. The elasticity estimates provide some very useful inference. For instance, changes in PLF as a result of a change in the percentage renewable in th generation mix suggest the removal of uncertainties in the predominatly hydro-dominated electricity systems which were vulnerable to seasonable droughts. This is because marginal additions from CCGT, which were not vulnerable to weather condition increased the load factor of plants.

3. The non-complementarity of market-based reforms with climate policies became evident from the marginal changes in all other performance markers with changes in the percentage of renewables in the generation mix. Non of the objectives were complementary with decarbonising the sector

4. The elasticity estimates also showed evidence of suppressed demand in SSA. This is inferred from the positive elasticity coefficients indicating that marginal increments in consumption per capita due to changes in plf and the level of network losses.

Summary Results

Variable	Coefficient	Std. Err
Log(plf)	0.98***	0.01
Log(losses)	-0.00	0.00
Log(cpc)	0.00	0.00
Log(re)	-0.00***	0.00
Electricity Law	0.03*	0.02
Unbundling	-0.01	0.02
Establishment of a Regulator	-0.06***	0.02
Private Prtcipation in the form of management contract, concessions or divestitures	0.04**	0.02
Regulatory Quality Index	-0.08***	0.01
_const	3.18***	0.02
U_sigma cons	-4.9876	.2597915
Log(gc) – inefficiency determinant	-0.30	0.11
V_sigma cons	-4.5259	.128035
Log(σ_u^2)	.0826 ***	.010729
Log(σ_v^2)	.1040 ***	.0066607
lambda	.7939***	.0159449

We recommend that SSA countries should shift focus from unbundling its sector to enhancing the powers of the sector regulator, while exploring alternate competition for the market models in its reform endeavours due to the strong sensitivity of the size of the electricity sector to (in)efficiency. We should take a cue from the top ten performing countries to priritise regional intergration and trade.