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Power Outages and Production Efficiency of Firms in Africa

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ABSTRACT

Literature shows that power generation capacity in sub-Sahara Africa is lower than that of any other region in the world and capacity growth has also stagnated. Africa currently faces major electricity shortages with a number of power outages which has the tendency of rendering many firms less efficient in their production. This study therefore seeks to find the impact of power outages on production efficiency of firms in Africa. The source of data is the World Business Environment Survey conducted by the World Bank. The analysis deployed stochastic production frontier and a two-tail Tobit models. The finding shows that the number of power outages experienced in a typical month has a negative impact on the production efficiency of firms in Africa. This call for immense investment projects in new generation capacity in order to ameliorate the negative effect of power crisis on production process of firms in Africa.

Keywords: Power Outages, Production Efficiency, Electricity, Africa
JEL Classifications: D22, D24, L94

1. INTRODUCTION

According to Abotsi (2015) energy is an integral part of any production process. However, Africa currently faces major electricity shortages with a number of power outages. Report by International Energy Agency (IEA) (2011) indicates that Africa presents the lowest electrification rate among developing countries with approximately 31% of people having access to electricity in sub-Sahara Africa, and about 14% of electrification rate in the rural areas. IEA (2009) reports that more than 77% of the rural population in Africa have no access to electricity and this rate reaches 88% for sub Saharan Africa countries. The power generation capacity in sub-Sahara Africa is lower than that of any other region in the world, and capacity growth has also stagnated (Eberhard et al., 2011). The World Bank enterprise surveys provide an expedient measure of the reliability of grid-supplied power. Data from the World Bank enterprise surveys indicate that most firms in Africa experience frequent power outages. The number of power outages experienced in a typical month could go as high over 100 times. Over the years, the World Bank survey of firms reported that electricity is a major obstacle to their activities. The data available show that power outage is worst in Angola, DRC, Ghana, Nigeria, Tanzania and Zambia. A more recent study by Abotsi (2015) shows that the number of power outages experienced in a typical month has a negative and significant impact on foreign ownership of firms in Africa. Though the supply of electrical power is unreliable throughout Africa the average price of power is double that in other developing regions (Eberhard et al., 2011). The average power tariff ($0.12 per kWh) in Sub-Saharan Africa is about twice the tariff in other parts of the developing world (Briceño-Garmendia and Shkaratan, 2010). These have the tendency of rendering many firms less efficient in their production.

The desire to promote production efficiency of a firm is important not only to firms but also to both economics theorist and economic policy makers. Efficiency of a firm typically refers to its success in producing as large as possible an output from a given set of inputs. The concept of inefficiency implies that any environmental factors that raise inputs requirements given output and firm technical characteristics will be said to cause inefficiency. This is because, in the absent of those factors, the firm would utilize fewer resources to produce the same output. Since energy is an integral part of most production process (Abotsi, 2015), its deficiencies has the potential of negatively affecting the production process which will culminate into production inefficiencies and low output. According to Cissokho and Seck (2013) power outages have the potential of affecting businesses activities which eventually lead to negative effects on productivity. The channels through which power outages affect industries include; the effect on the production process (efficiency channel), the extra cost to firms in search of alternative sources of energy and the costs associated with the replacement or repair of broken machines and equipment as a result of the power outages and finally the effect on the quality of a good or service produced (quality channel) (Cissokho and Seck, 2013). This is why this study attempts to find out the impact of the number of power outages experienced in a typical month on the production efficiency of firms in Africa.

According to Alam (2013) increases in the incidence of power outages reduce the output and profits of some electricity-intensive industries. Also according to Eberhard et al. (2011) the weakness of the power sector in Africa has constrained economic growth and development in the region. Moreover the International Labor Organization (ILO) (2014) reports that African economic growth rate in 2013 proved too low to generate sufficient employment opportunities for a rapidly growing population, (ILO, 2014). Meanwhile the engine through which the growth objectives of developing countries can be achieved are these firms (Abotsi et al., 2014). Therefore the need to explore the influence of power outages on firm production efficiencies cannot be overemphasized. Studies elsewhere on power outages focused on the impact of power outages on output of firms (Alam, 2013) and the costs of power outages (Adenikinju, 2005; Beenstock et al., 1997; Bernstein and Heganazy, 1988; Caves et al., 1992; Lee and Anas, 1992). Only few of these studies looked at the impact of the number of power outages on production efficiency of firms. For example, Cissokho and Seck (2013) deployed Data Envelopment Analysis (DEA) to show that power outages have negative effects on scale efficiency. But the use of DEA has the drawback of assuming that all errors in data measurement and other random disturbances are interpreted as indicating technical inefficiency. This study therefore contributes to literature by deploying stochastic frontiers analysis (SFA) to establish the impact of the number power outages on the production efficiency of firms in Africa.

Using the SFA in the estimation of the efficiencies and the Tobit estimation technique, the empirical results show that the number of power outages has a significant negative effect on production efficiency of firms. The rest of the paper present the theoretical framework of technical efficiency, literature review and the methodology deployed. This will be followed by the presentation and discussion of the results and finally the conclusion.

2. THEORETICAL FRAMEWORK OF FIRM TECHNICAL EFFICIENCY

Three quantitative approaches have been developed in literature in the measurement of production efficiency. These approaches include parametric which can be deterministic or stochastic, non-parametric which is based on DEA and productivity index which is based on growth accounting and index theory principles (Coelli et al., 1998). Estimating technical efficiency can be done using two alternative methodologies. These include the deterministic and stochastic models. A usual approach in efficiency studies employs SFA, which allow for the measurement of the level of inefficiency. The deterministic model has the drawback of assuming that all deviations from the maximum are due to technical inefficiency. Thus, errors in data measurement and other random disturbances in the dependent variable are interpreted as indicating technical inefficiency. A stochastic model is totally explicit about its underlying assumptions and takes into account measurement errors and other noise in the data. Technical efficiency refers to the ability of a firm to produce maximum output given its inputs and thus anything contrary is inefficiency. Technical efficiency is characterized by the relationship between observed production and potential production of a firm. The optimum is defined in terms of production possibilities (frontier) and a relative measure of efficiency is a function of distance to the frontier.

The SFA approach requires that a functional form be specified for the frontier production function. The stochastic frontier model proposed by Aigner et al. (1977) and Meeusen and van den Broeck (1977) includes a random term representing the noise.

The model for the i^{th} firm is written as follows:

$$ln(y_i) = f\left(x_i, \beta\right) + v_i - u_i \quad (1)$$

Where i indexes producers; y_i is >0 and is an output scalar; x_i is a vector consisting of inputs and an intercept; β is a vector of coefficient estimates; $u_i - N(u, s_u^2)$ is a random variable representing technical inefficiency associated with production of firm i; and $v_i - N(0, \sigma_u^2)$ is a stochastic error term.

There are two objectives in stochastic frontier analysis (Kumbhakar and Lovell, 2000). The first is the estimation of a stochastic frontier function which serves as a benchmark to estimate technical (or allocative) efficiency of producers (Atkinson et al., 2001; Battese and Coelli, 1988; Kumbhakar et al., 1989). The second objective is the inclusion of exogenous variables that are neither inputs nor outputs to the production process, but which however affect producer performance with the intent to identify the determinants of efficiency (Ali and Flinn, 1989; Battese and Coelli, 1995; Kalirajan, 1981; Pitt and Lee, 1981). This study estimates the technical efficiencies of firms deploying the stochastic production frontier without the inclusion of exogenous variables.

The efficiency of i^{th} firm is defined in terms of the ratio of observed output to maximum output conditional on the levels of inputs used. The technical efficiency of the i^{th} firm is given by $TE_i = \exp(-u_i)$ and takes values between 0 and unity. The value 1 defines a technically efficient firm. Hence the efficiency of firm i is expressed as:

$$TE_i = \ln y_i \big/ \ln y_i^* = \frac{\left(f(y_i, p; \beta)\exp(v_i - u_i)\right)}{\left(f(y_i, p; \beta)\exp(v_i)\right)} = \exp(-u_i)$$

3. LITERATURE REVIEW

3.1. Determinants of Firm Efficiency

Several studies according to Caves and Barton (1990) and Caves (1992) have developed a strategy for classifying the determinants of efficiency. These classifications as cited in Gumbau-Albert and Maudos (2006) include factors external to the firm such as the degree of competition existing in the markets in which they operate. The next is the characteristics of the firm such as size, type of organization and the advantages of the location of the firm among others. The next is the dynamic disturbances or deviations from the firm's long term equilibrium situation. These disturbances may be due to the evolution of the demand faced by the firm or firm's production strategies such as the degree of technical innovation. The last is public verses private ownership of the firm (Gumbau-Albert and Maudos, 2006).

According to Sinani et al. (2007) theoretical and empirical literature on firm performance and privatization has identified other variables as determinants of firm performance and consequently firm efficiency (Aw et al., 2000; Brown and Earle, 2001; Djankov and Murrell, 2002; Frydman et al., 1999). These determinants include investment in fixed capital, soft budget constraints, firm trade orientation, the quality of labor and competition. Based on the theoretical and empirical literature on the determinants of firm efficiency and data availability, the following factors; the number of power outages, corruption (informal payment or bribes) and firm characteristics such as exporter, competition, years of functioning (age of firm) have been included in this study to influence the technical efficiency of the firms. These factors are discussed below. Those factors that enhance firm technical efficiency are expected to decrease the inefficiency of the firm.

3.2. Electricity Situation and Power Outage in Africa

According to Eberhard et al. (2011) an estimated 93% of Africa's economically viable hydropower potential (937 TWh per year) remains unexploited. Much of these potential is located in the Democratic Republic of Congo, Ethiopia, Cameroon, Angola, Madagascar, Gabon, Mozambique, and Nigeria. Also most Sub-Saharan African countries have built thermal power stations but rely on imported petroleum and gas resources. Oil reserves in Sub-Saharan Africa accounts for <5% of global oil reserves and gas reserves make up <4% of the world's total proven reserves (British Petroleum (BP), 2007). Another source of electric power is nuclear energy but on the African continent, only one nuclear power plant has been built. This is the 1,800 MW Koeberg station situated in South Africa. Africa's natural uranium reserves accounts for approximately one-fifth of the world's total and are found mainly in South Africa, Namibia, and Niger. In addition, Africa has abundant renewable energy resources, particularly solar and wind (Eberhard et al., 2011). In spite of electricity generation potential of Africa continent, the combined power generation capacity of the 48 countries of Sub Saharan Africa is 68 gigawatts and this falls to 28 gigawatts once South Africa is excluded. Owing to the population and economy growth of the whole continent, the total primary energy supply is constantly increasing (Mandelli et al., 2014). Northern Africa has almost 4 times lower consumption of electricity per capita than South Africa. Middle and Western Africa have similar electricity consumption per capita but the different amount of population accounts for the difference in the total electricity generated.

Despite the lower population in Eastern Africa, the slightly higher consumption in Eastern Africa leads to greater electricity generation than Western Africa (Mandelli et al., 2014). The capacity growth for the past three decades according to Yepes et al., (2008) has been mostly stagnant and this has resulted in widening the gap between Sub-Saharan Africa and the rest of the developing world. External factors such as drought, war and conflict have worsened the power situation in Sub-Saharan Africa (Eberhard et al., 2011). Recent fall in international oil prices which is expected to ameliorate the situation has not achieved much due to the fast growing demand for electricity on the continent. Countries such as Ghana, Nigeria and South Africa, are experiencing a power crisis due to rapid growth in electricity demand as a result of increased urban/rural electrification projects together with underinvestment in new generation capacity. These, among other factors have accounted for frequent power outages experienced by African countries with its attendance effect on firm's productivity. According to Moyo (2013) Sub-Saharan African firms often identify electricity as a main constraint in doing business. It is therefore expected in this study that number of power outages experienced in a typical month will have a negative impact on firm's technical efficiency.

3.3. Corruption

Earlier studies on corruption and firm efficiency are based on the models by Dal Bo and Rossi (2007) and Yan and Oum (2011). In their model, Dal Bó and Rossi (2006) focused on how corruption affects the level of price negotiation effort, labor use and managerial efforts in deriving the effects of corruption on firm efficiency. In their study they try to prove that assertion that firms in more corrupt environments will be more inefficient. Yan and Oum (2011) investigate the impacts of institutional arrangements on cost efficiency and found that politicians in low corrupt environments can influence decision making in order to pursue political goals. Such influences together with the lack of internal incentives deter the efforts by managers to exploit more efficient inputs allocation. The cost efficiency can be affected by technical inefficiency which corresponds to an over-utilization of inputs given outputs and input mix. Abrate et al. (2013) conclude that, both studies by Dal Bo and Rossi (2007) and Yan and Oum (2011) are built on the idea that corruption leads to weak incentives and therefore to low efficiency levels, but they are different as to the underlying mechanisms (external versus internal) at stake. Abrate et al. (2013) finds that corruption significantly increases cost inefficiency. Research has shown that firms in more corrupt environments will be more inefficient and so it is expected in this study that corruption will have a negative impact on firm's technical efficiency.

3.4. Age of the Firm

Deraniyagala (2001) argue that the effects of firm age on efficiency are ambiguous. On the one hand, a positive relationship can be expected due to learning-by-doing which occurs with cumulative production experience. On the other hand, older firms may have older capital equipment and may have developed inefficient production routines and practices, leading to a negative impact of age on efficiency. Research by Deraniyagala (2001) found that though age was positive but it was not significant. It is expected in this research that age of firm explains a good portion of technical efficiency variation across firms, and that technical efficiency increases with age.

3.5. Export-Orientation

Previous studies have found export-orientation to improve efficiency at the firm level (Aw and Batra, 1998; Caves and Barton, 1990; Chen and Tang, 1987; Rodrik, 1995). Deraniyagala (2001) found export to significantly have a positive impact on the firms' efficiency indicating that exporters have higher efficiency levels than non-exporters. The intuition is that exporting has a positive effect on technical efficiency because it exposes firms to international competition and allows them to benefit from scale economies and therefore exporting is expected in this study to explain a good portion of technical efficiency variation across firms with positive effect on technical efficiency.

3.6. Competition of Firms

Microeconomics theory suggest that perfect competition reduces inefficiency and this is based on the premise that there is a large number of firms co-existing in the same market, using the same technology, making a homogeneous product with both producers and consumers having perfect information on the conditions of the market. Carlsson (1972) and Caves and Barton (1990) maintain that the presence of competitors in an economy increases the diffusion of information and technical knowledge that could be considered to be a source of experience. This can increase the efficiency of the agents participating in this economy. Gumbau-Albert and Maudos (2006) found that external competition acts in favor of efficiency. It is consequently expected that competition among firms explains a good portion of technical efficiency variation across firms, and that technical efficiency increases with competition.

4. METHODOLOGY

The study is based on secondary data and the main source of data is the World Business Environment Survey conducted by the World Bank. The research seeks to find the general impact of power outages on production efficiency of firms in Africa. These firms are made up of all sectors including the manufacturing, services and retail. Though the demand for electricity varies significantly across the various industries, literature shows that power outages have a homogenous impact on electricity-intensive firms (Fisher-Vanden et al., 2012; Reinikka and Svensson, 2002). Nonetheless, Alam (2013) holds a contrary view. In all 2,755 firms are included in the analysis and the countries included in the study are Angola, Botswana, Congo D. R., Ethiopia, Ghana, Mali, Nigeria, Tanzania, Zambia and Zimbabwe. The years include 2010, 2011 and 2013. This choice is based on data availability.

To show that electric power outrages leads to production inefficiency of firms in Africa, the model in Equation (1) is deployed. The first stage of the analysis is the estimation of the technical efficiencies of firms deploying the stochastic production frontier. To render the model in Equation (1) operational, both the Cobb-Douglas and Transcendental-logarithm (translog) production functions are chosen to test for the appropriate specification that best fits the data. Whereas Cobb-Douglas production function can only allow constant return to scale and but easy to estimate and interpret, Translog production functions has more flexible functional form (less restrictions on production elasticities and substitution elasticities) but more difficult to interpret. Taking natural logarithms, the two functional forms for the stochastic frontier production function to be estimated becomes:

$$\ln y_j = \alpha_0 + \sum_{j=1}^{3} \alpha_j \ln x_j + (v_i - u_i) \tag{2}$$

$$\ln y_j = \alpha_0 + \sum_{j=1}^{3} \alpha_j \ln x_j + \frac{1}{2}\sum_{j=1}^{3}\sum_{k=1}^{3} \gamma_{jk} lnx_j lnx_k + (v_i - u_i) \tag{3}$$

Where lny_i is the natural logarithms output, lnx_j are natural logarithms of inputs, α_0, α_j *and* γ_{jk} are parameters to be estimated and finally v_i and u_i are the two components error terms specified above. This assumes log (output) to be linear in the sum of the log (inputs). This functional form allows the coefficients to be interpreted as input elasticities, meaning each α_j represents the percentage change in output due to a 1% increase in input *j*. A cross-sectional data is deployed in both the Cobb-Douglas production frontier and the Translog production frontier. The measure of output is usually straightforward once the outputs of a firm can be identified and measured. It becomes more difficult to measure the outputs especially when the firm is involved in delivering of services. However, once data on value of production or sales of the firms are available, these can be used as measures of output. Therefore in this study the output *(y)* represents total annual sales of the firms. A classification of inputs frequently used involves five categories (Coelli et al., 2005). These classifications of inputs include capital, labor, energy, material inputs and purchased services. In this study the inputs (x_j) represent capital, labor and energy. Labor and capital are the two main inputs of primary interest. Labor is captured in this study by the number of employees. Capital is captured as total of annual expenditure for purchases of equipment and annual expenditure for purchases of land and buildings. The last input variable is energy which is captured as the expenditure on electricity and fuel.

The second stage of the analysis is the identification of the factors that influence this technical efficiency of firms. The ratio of observed output to the corresponding stochastic frontier output is the most common output-oriented measure of technical efficiency (Coelli et al., 2005). The factors that enhance firm technical efficiency are expected to decrease the inefficiency of the firm. The firm technical efficiency scores are regressed on the factors that are likely to affect the technical efficiency of firms using a two-tail Tobit model in order to identify the inefficiencies of the firms. The two-tail Tobit model was estimated because the firm technical efficiency scores range between 0 and 1 (Ray, 2004). These explanatory variables include factors that can affect the technical efficiency of the firms such as number of power outages in a month, percentage of total annual sales paid as informal payments (bribes), competition against other firms, export oriented firms as well as firm characteristics such as age of firm.

The benchmark Tobit equation in a linear form, with a constant term, is as follows:

$$\begin{aligned} &Efficiency\ Scores_i = \beta_0 + \beta_1 Number\_power\_outages_i + \\ &\beta_2 Informal\_payment_i + \beta_3 Age\_business_i + \\ &\beta_4 Competition_i + \beta_5 Export_i + \varepsilon_i \end{aligned}$$

5. EMPIRICAL RESULTS

The descriptive statistics of variables used in the analysis is shown in Table 1. The average number of power outages experienced in a typical month is almost 24. The results show that the percentage of total annual sales paid as informal payments to officials or bribes is 3.1%. About 98% of the firms face competition in the market and 0.9% of the firms are export oriented firms. The total number of observations is 2,755 and the average age of these firms is 15 years.

5.1. Results of Stochastic Production Frontier Model

The signs of parameters (α_i) estimated are all expected with exception of negative estimate of the labour variable in the case of translog function (Table 2). That is, technical progress in the translog function tends to diminish the usage of labor, but is associated with the increase in the utilization of the other inputs. The parameter estimates for the Cobb Douglass function indicate that the elasticities of labor, energy and capital are 0.38, 0.33 and 0.41 respectively. The greatest elasticity observed is that of capital. This indicates the intense relationship that exists between production and capital. The labor variable reveals the second major elasticity, confirming the importance of labor to the production process. The elasticity of energy also shows a substantial contribution to the production process.

The parameter γ, defined as:

$\gamma = \frac{\sigma_u^2}{\sigma^2}$, Where $\sigma^2 = \sigma_v^2 + \sigma_u^2$ specifies whether all deviations from the stochastic frontier are due to technical inefficiency or random error. A gamma (γ) close or equal to unity is an indication that all deviations from the stochastic frontier can be attributed to technical inefficiency. Nonetheless, a gamma (γ) close to zero indicates that all deviations from the frontier can be attributed to random error (noise) (Coelli et al., 2005). The estimated gamma (γ) for translog and Cobb Douglass models is 0.0001614 and 0.0001698, respectively. These indicate that all deviations from the model are as a result of random error. The values of Akaike's information criteria (AIC) and Bayesian information criteria (BIC) indicates which of the models better fits the model. A smaller AIC or BIC value indicates a better-fitting model. The results indicate that translog production function with AIC or BIC values; 8772.31 and 8849.28 respectively, is more preferable than Cobb-Douglas production function with AIC or BIC values; 8944.965 and 8986.414 respectively. Since the sizes of the firms differ, it is likely that this size variation will introduce heteroscedasticity into the idiosyncratic error term (v_i). When heteroscedasticity in v_i is neglected, it does not produce any bias for the frontier's parameters estimates, but it leads to biased inefficiency estimates. To check this, a conditional heteroskedastic half-normal model, with the size of the firm as an explanatory variable in the variance function for the idiosyncratic error is estimated. At 1% level of significance, the output (Table 2) indicates that the variance of the idiosyncratic error term is a function of firm size.

5.2. Results of Tobit Model

The dependent variable in the Tobit model represents the efficiency scores from translog and Cobb Douglas estimations. The number of observations in the dataset for which all of the response and predictor variables are non-missing is 2755. The log likelihood of the fitted model (34995.229 and 32479.022 for translog and Cobb Douglas estimations respectively) is used in the likelihood ratio (LR) Chi-Square test of whether all predictors' regression coefficients in the model are simultaneously zero (Table 3). The LR Chi-square test that at least one of the predictors' regression coefficients is not equal to zero, is 20.37 and 28.22 for translog and Cobb Douglas estimations respectively. The P-value (0.0011 and 0.0000 for translog and Cobb Douglas estimations respectively) from the LR test indicates that the null hypothesis that all of the regression coefficients are simultaneously equal to zero is rejected.

The coefficients of Tobit regression (Table 3) have similar interpretation as that of OLS. But the linear effect is on the uncensored latent variable. The focus of this research is to find the qualitative effect of the explanatory variables on firm technical efficiency. Number of power outages was found to have a negative effect on efficiency. The parameter (β_1) was found to be significant at 10% using the efficiency scores from translog estimation and at 5% using the efficiency scores from Cobb Douglas estimation. This finding is consistent with the study by Alam (2013) that suggest that increases in the incidence of power outages reduce the output and profits of some electricity-intensive industries. More specifically the finding is also consistent with the findings by Moyo (2013) and Cissokho and Seck (2013) that shows that power outages have potential negative effects on productivity. This result seems to explain why countries which experience high number of power outages in a typical month are less likely to attract foreign investors to own firms in Africa (Abotsi, 2015). The percentage of total annual sales of firms paid as informal payments to public officials has a negative and significant effect on efficiency. The parameter (β_2) was found to be significant at 1% using the efficiency scores from either translog estimation

Table 1: Description statistics of variables

Variable	Observations	Mean	SD	Minimum	Maximum
Total annual sales	2755	2.38E+11	1.23E+13	5000	6.48E+14
Labor	2755	33.05445	143.4193	1	5074
Energy	2755	2.11E+07	4.88E+08	115	2.00E+10
Capital	2755	4.33E+07	6.91E+08	31	2.60E+10
Informal payment	2755	3.067949	4.913125	0	75
Number of power outages	2755	23.94882	18.40203	0	300
Age of business	2755	14.80726	10.74908	1	158
Compete with other firms	2755	0.9818512	0.1335137	0	1
Export	2755	0.0094374	0.0967043	0	1

SD: Standard deviation

Table 2: Results of stochastic production frontier analysis

Variables	Parameter	Translog estimation ln_sales	Cobb Douglass estimation ln_sales
ln_Labour	α_1	−0.494***	0.381***
		(0.146)	(0.0267)
ln_Energy	α_2	0.212**	0.328***
		(0.0904)	(0.0142)
ln_Capital	α_3	0.139	0.411***
		(0.0926)	(0.0137)
ln2_Labour	α_4	−0.0119	
		(0.0182)	
ln2_Capital	α_5	0.0324***	
		(0.00364)	
ln2_Energy	α_6	0.0298***	
		(0.00511)	
ln_LK	α_7	0.0235	
		(0.0147)	
ln_LE	α_8	0.0495***	
		(0.0147)	
ln_KE	α_9	−0.0557***	
		(0.00620)	
Constant	α_0	9.476***	5.780***
		(0.670)	(0.204)
Gamma (γ)		0.0001614	0.0001698
Size		0.00225***	0.00251***
		(0.000334)	(0.000344)
AIC		8772.306	8944.965
BIC		8849.282	8986.414
Observations		2,755	2,755

Standard errors in parentheses. ***P<0.01, **P<0.05, AIC: Akaike's information criteria, BIC: Bayesian information criteria

Table 3: Results of Tobit analysis

Variables	Parameter	Translog_ efficiency scores	Cobb_efficiency scores
Number_power_ outages	β_1	-1.35×10^{-09}*	-4.27×10^{-09}**
		(7.66e-10)	(1.91e-09)
Informal_payment	β_2	-7.54×10^{-09}***	-2.27×10^{-08}***
		(2.87e-09)	(7.16e-09)
Age_business	β_3	9.64×10^{-10}	3.22×10^{-09}
		(1.31e-09)	(3.28e-09)
Competition	β_4	2.85×10^{-07}***	$8.03\text{-}10^{-07}$***
		(1.05e-07)	(2.63e-07)
Export	β_5	-1.18×10^{-07}	9.80×10^{-08}
		(1.46e-07)	(3.64e-07)
Constant	β_0	0.999***	0.998***
		(1.10e-07)	(2.74e-07)
Sigma (σ)		7.36×10^{-07}***	1.84×10^{-06}***
		(9.92e-09)	(2.47e-08)
Log likelihood		34995.229	32479.022
LR Chi-square (5)		20.37	28.22
P>Chi-square		0.0011	0.0000
Observations		2,755	2,755

Standard errors in parentheses. ***P<0.01, **P<0.05, *P<0.1, LR: Likelihood ratio

or from Cobb Douglas estimation. This finding supports earlier findings by Abrate et al. (2013), Dal Bo and Rossi (2007) and Yan and Oum (2011) that indicated that corruption has a negative effect on efficiency. The results also show that competition among firms explains a good portion of the technical efficiency variation across firms. Competition among firms was found to have a positive effect on efficiency. The parameter (β_4) was found to be significant at 1% using the efficiency scores from either translog estimation or from Cobb Douglas estimation. The finding supports Gumbau-Albert and Maudos (2006) who found external competition to act in favor of efficiency. Since the parameters, β_3 and β_5 were found not to be significant at all levels, it means there is not enough evidence to conclude that age of firm and export oriented firms have effect on efficiency.

6. CONCLUSION

The general deficiency of the power sector in Africa has constrained Africa's economic and social development (Eberhard et al., 2011) with its adverse effect on employment. It cannot be denied that Africa's economic and social development depends mostly on the activities of small and medium scale enterprises. Therefore the report by the World Bank enterprise survey that electricity is a major obstacle to firm activities must be a matter of concern to all stakeholders. This study tried to find out the impact of the number of power outages experienced in a typical month on the production efficiency of firms in Africa. The finding shows that the number of power outages experienced in a typical month impact negatively on firm production efficiency. Eberhard et al. (2011) projects that installed capacity in Africa will need to grow by more than 10% annually (or more than 7,000 MW a year) just to meet Africa's suppressed demand and keep pace with projected economic growth. Since deficient power infrastructure and power outages dampen economic growth it is recommended that leaders in Africa should endeavor to exploit to full capacity the electricity generation potential in their various countries. This call for immense investment projects in new generation capacity. This investment will ameliorate the devastating effect of power crisis on production process of firms in Africa. The limitation of the study includes the assumption that all firms have the same production elasticities and that substitution elasticities equal 1.

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