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Electricity load shedding: An econometric analysis of the productivity of firms in the manufacturing sector in Lusaka

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Abstract

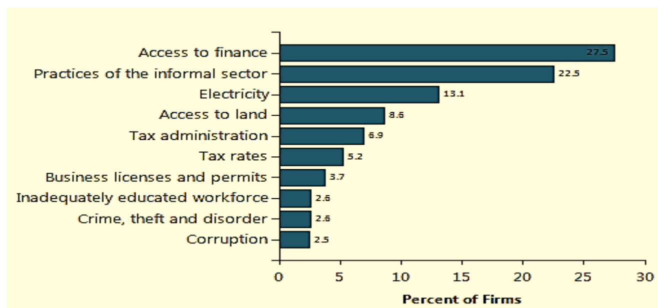
The main aim of this paper was to empirically analyse the impact of electricity load shedding on the manufacturing sector in Zambia. Using cross-section data from the 2014 World Bank Enterprise Survey, this study used the ordinary least squares method of estimation to empirically analyse the impact of electricity load shedding on the manufacturing sector. It was established that load shedding, on average, has a negative and significant impact on the productivity of firms, controlling for other production factors. However, different manufacturing firms were found to react differently to load shedding depending on the sub-sector. Given that power disruptions are unfavourable to firm productivity and the importance of the manufacturing sector to the economy, it is clear that Zambia needs to diversify from hydropower to alternative sources of energy.

Keywords: Load shedding, Firm productivity, Econometric analysis

Introduction

Electricity is a form of energy that is not only an essential input in most production processes, but has also become a necessity for most households across the globe. The total installed capacity in Zambia currently stands at 2,202.75 MW indicating a significant increase over the past decade, arising from new, as well as expansion projects (ZESCO, 2015) [6]. However, Zambia has been experiencing load shedding as a result of the deficit in the generation of electricity that has been outstripped by the ever growing demand. From 2015, however, load shedding increased drastically, a situation which ZESCO (2015) [6] attributed to low water levels in the reservoirs because of lower than average rainfall received in the 2014/15 season. As at December 2015, the country was facing a deficit of about 660 megawatt (MW), which was equivalent to about one quarter of its generation capacity (IFIZ, 2015) [12]. In dealing with this deficit, ZESCO Limited embarked on a nationwide load shedding programme in which power was cut to customers for periods ranging from eight to fourteen hours per day. This was done on a nationwide rotating schedule in order to avoid total power system failure (ZESCO, 2015) [6].

The Zambian manufacturing sector consumes about 20% of the total hydroelectricity, standing second to mining which accounts for about 50% of the total consumption (Nsupila and Chimfwembe, 2015) [19]. Manufacturing firms also identify electricity load shedding as the third most important operational constraint in comparison to other factors such as access to finance, land and business permits (World Bank, 2014). Figure 1 below illustrates the major obstacles for firms in comparison to inadequate electricity supply.



Source: World Bank (2014)

Fig 1: Proportion of Firms Identifying Access to Constant Electricity as a Constraint in Relation to other Factors

Load shedding has aggregately been said to reduce average output in an economy by about 10%, but because inputs in some sectors can be stored during outages, productivity losses are slightly smaller in some sectors than in others (Alcott *et al*, 2014). According to Park *et al*. (2014) [20], the ultimate impact of power shortages is reduced economic growth and development. However, Mbunwe (2014) [17] argued that the negative impact of load shedding on industry or firms is dependent on whether or not firms have alternative sources of electricity. Mbunwe (2014) [17] added that firms that are able to generate their own electricity during periods of load shedding are affected differently from those that do not have. Firms that can generate their own power will be able to sustain normal operations and production, though at a higher cost. Meanwhile, firms that cannot afford to use alternative sources of power are forced to slow or shut down operations.

Since the potential losses from load shedding would be large, many firms might insure themselves against outages by purchasing generators or otherwise substituting away from grid electricity, thereby cushioning the effects of load shedding on productivity but not necessarily on profitability (Van Der Nest, 2015). One potential a-priori is that because electricity is an essential input, most factories cannot produce anything without power for lights, motors and machines, and as such, shortages could significantly reduce output.

Some of the immediate effects of load shedding felt on the economy have been the laying off of workers in excess of 5,000, particularly in the mining sector, as firms cut production amid weakening copper prices (EAZ, 2015) [5]. As firms substituted reduced electricity supply from ZESCO with relatively expensive alternative sources of power, the cost of production for these firms has increased which in aggregate has also contributed to a depressed growth outlook for the Zambian economy from an initial forecast for 2016 from 7 % to about 4.6% (Ibid).

Furthermore, the EAZ (2015) [5] also indicated that load shedding of power had caused damage to industrial machinery, thereby increasing machine repair costs, which were unbudgeted for. It is undisputed that electricity is an essential input in most production processes; hence its inadequate supply poses a challenge to the operations of a firm. Short supply from the conventional grid supply by ZESCO Limited, either in quantity or duration of constant supply, is expected to have negative ramifications on firm productivity. With the growing economy in Zambia, particularly industrialisation, demand for electricity appears to have outstripped supply, leading to load shedding. However, the aggregate impact of electricity load shedding to manufacturing companies has not been extensively ascertained empirically. In view of the above, an empirical analysis of the impact of electricity load shedding on the manufacturing sector in the country, specifically in Lusaka, is necessary.

Some stakeholders such as the Intellectual Forum Institute of Zambia (IFIZ, 2015) [12] indicated that there was need for statistical data on the economic impact of load shedding in Zambia in order for the public to make effective decisions (IFIZ, 2015) [12]. IFIZ (2015) [12] also acknowledged that independent studies were conducted on the effect of energy deficits as a whole on firm welfare but very few have given an empirical analysis, especially in Zambia. In filling this gap, this paper will focus on providing empirical estimates of the effects of load shedding on firm productivity in the manufacturing sector with a special focus on firms within Lusaka Province. It is important to provide some firm level estimates of the impact that load shedding has on the manufacturing sector vis-à-vis productivity to inform firm level decision making.

2. Literature Review

Limited availability and inadequate access to stable and reliable power, remains one of the greatest constraints to the growth of the manufacturing sector and other industries in Zambia. Standing at 50 days per year, power outages in Zambia are significantly higher than the average for middle income countries which stands at 6 days per year and other resource rich countries which stand at 15 days per year (Nsupila and Chimfwembe, 2015) [19]. Aschauer (1989) [2] studied the relationship between aggregate productivity, stock and flow of Government spending variables in the US economy for the period 1949-85. In his estimations, he treated Government spending on public capital, particularly electricity generation and supply, as one of the inputs in the production function and proxy for infrastructure variables, like electricity. Findings suggested that there was a significant positive relationship between output per unit of capital input, the private labour-capital ratio, and the ratio of the public capital stock, including electricity generation and supply infrastructure, to the private stock at firm and household level.

Cissokho and Seck (2013) [4] emphasised that since electricity was a significant component of virtually any production process, limited supply has the potential to directly and indirectly affect the economic activities of firms. It is, therefore, possible that one of the analytical frameworks that may be used to ascertain this impact of load shedding is a production function in which electricity contributes directly to firms' output as a separate input, and indirectly as a determinant of the extent to which equipment is used.

Scott *et al*. (2014) [21] suggest that, in middle and lower income countries, firms themselves consider access to electricity to be one of the biggest constraints to their business. They add that inadequate electricity services can constrain business operations as supply of electricity may simply be unavailable. Their results indicated that the most significant impacts to productivity can be due to forced and unexpected halts in manufacturing processes, including running assembly lines and using machinery.

Grimm *et al*. (2012) [10] highlight the point that electricity infrastructure and consumption generally grow with productivity and growth, but causation is difficult to establish. To this end, it is clear that electricity enhances productivity at both macro and microeconomic levels. This notion was supported by Mayer-Tasch *et al*. (2013) [16] who indicated that firms with access to electricity tend to have higher productivity than firms without. In addition, Mayer-Tasch *et al*. (2009) indicated that infrastructure quality overall has a significant impact, at least as important as factors such as access to finance, and as such load shedding seems to be the infrastructure element with the strongest negative effect on productivity. This notion was supported by Hulten (1996) [11] and Moyo (2012), who found out that with electricity access, the impact of electricity insecurity on productivity varies depending on factors related to both the external context that a firm operates in and its internal capabilities.

On the other hand, Cissokho and Seck (2013) [4] discovered that the impact of load shedding was not universally negative. They found that in Senegal, the outages had generated some positive effect on manufacturing firms, because outages stimulated better management practices to mitigate the negative impact of power cuts. Further, they also found that less efficient and lower productive firms had gone out of business leaving only the efficient ones. Estache *et al*. (2005) [9] made one of the first attempts to conduct a more systematic, quantitative assessment of the importance of Sub-Saharan Africa's infrastructure. They found that electricity, water, roads, and telecommunications are crucial factors in promoting growth.

In addition, Esfahani and Ramirez (2003) [8] postulated that Sub-Saharan Africa's poor growth performance is, in part, related to under investments in electricity infrastructure**.** In addition, ERB (2014) and KPMG (2014) also attribute the inadequate supply of electricity to limited investments and lack of modernisation of existing power plants. IAPRI (2016) argued that the very little diversity in the energy generation mix compared to hydro stating that only Angola, Zimbabwe and Tanzania generate significant amounts of power from other generation sources like coal, natural gas, oil, renewable sources and nuclear power.

Adenikinju (2005) [1] pointed out that the problem with Africa's energy sector is not that of scarcity, but lack of infrastructure, proper financing mechanisms, and regulations that are important to make markets work in support of energy for sustainable development.

Kawesha (2015) [14] indicated that in Zambia, load shedding had disrupted production across all industries in the country, and that companies were unable to reach their sales volume targets. In this regard, he claimed that the production of goods and services had declined to the range of between 10% to 50% for industrial players not using alternative sources of energy, and 7% to 20% for companies using alternative sources of energy. Similarly, using the measure of multifactor productivity to estimate the impact that load shedding by ZESCO Limited has had on the manufacturing industry in Zambia. Sing'andu (2009) [22] showed that mining and manufacturing were the main sectors responsible for increased demand for electricity in the country, and that the mining sector alone consumed about 50% of the power generated by ZESCO. He also found that the demand for power by firms in the manufacturing sector kept on increasing due to new investments. He further argued that the sector consumed about 25% of the power and this share is expected to increase in the near future due to increased commercial and industrial activity in the country.

Like the rest of the continent, majority of Zambia's water resource and minerals such as coal, remain untapped for electricity generation (Nsupila and Chimfwembe, 2015) [19]. This is in part what the EAZ (2015) [5] has attributed to the increase in load shedding as a result of increased demand coupled with inadequate generation capacity. In addition, the EAZ (2015) [5] pointed out the negative impact that load shedding was having on the productive sectors of the economy, particularly manufacturing. In the same vein, Sing'andu (2009) [22] in his analysis of the impact that load shedding has had on productivity in Zambia, particularly Lusaka, indicated that whenever load shedding was in effect, productivity declined. He further claimed that the longer the duration of the power outages, the higher the decline in production by firms.

According to Sing'andu (2009) [22], it is clear that there is indeed a causal relationship between productivity and electricity load shedding. However, the model used by Sing'andu (2009) [22] appeared somewhat skewed as it concentrated entirely on power as the major input into production, notwithstanding that other inputs such as labour are in most cases correlated to power usage and in some cases can be used interchangeably. In fact, ZIPAR (2015) argued that power cuts have the potential to increase firms' labour costs as a result of overtime pay for employees that work outside their standard work hours, incur additional costs of wasted raw materials and damage to equipment as a result of sudden power outages.

According to Moyo (2012), such a trend is mainly due to the difficulty in storing food related inputs and products once they are in the production line and a power outage occurs. Further, Moyo (2012) concluded that the hardest hit among these food processing firms are those without or relying on shared generators.

3. Methodology

Data

The study used firm-level cross sectional data of the World Bank's Enterprise Survey (2014) [24]. The total number of manufacturing firms covered by the World Bank Enterprise Survey[1]was 720 firms across the country. Of these, 381 firms based in Lusaka Province (see Figure 3) were taken as the population for this study. From the population, firms were selected using a non-probability accidental or grab/convenience sampling technique[2]. A sample of 52 firms which had provided all the necessary information during the survey was drawn from the population. Using the non-probability accidental sampling technique, the 52 firms were reached by narrowing down to those that were in the mainstream productive sub-sectors. These subsectors include; food processing; non-metallic mineral products; textiles; wood processing; chemicals; plastics and rubber etc. In addition, some secondary data on the sector was also obtained from the Zambia Association of Manufacturers (ZAM), as well as the Central Statistical Office (CSO) for comparative purposes.

The main focus of this study was to establish the relationship between electricity (source, self-generation, outages, estimated losses, etc.), and production together with cost-related issues (turnover, market destination, type, costs, investment, market structure, capacity utilisation, etc.). In line with the literature reviewed above, the study used the total annual sales as the dependent variable to measure productivity of the firm. The independent variables were; total labour costs (wages, salaries and bonuses), net book value of capital stock, total cost of raw and intermediate materials, number and duration of load shedding incidents, summarised using the percentage of electricity use from alternative power sources (generators). Other covariates to represent technical capacity associated with firm age, as well as firm ownership (local or foreign) were also used as independent regressors.

Descriptive statistics of the data obtained from the survey are summarised in Table 3 below.

Table 3: Summary of Descriptive Statistics

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Ln Y	52	16.5881	24.8008	20.3085	2.2086
Ln L	52	13.7102	22.2740	18.2913	1.8826
Ln M	52	15.4249	24.2786	18.3274	2.1348
Ln K	52	10.5966	24.7486	18.0509	2.6532
Ln E	52	0.6931	3.9120	2.6386	0.9580
Ln X	52	1.6094	4.0604	2.7969	0.5079
Own	52	-9.0000	100.0000	15.7120	36.6620

Source: Authors' Own Compilation (2016), Gretl Output

Estimation Strategy

[1]The Enterprise Survey (2014) had 2031 Lusaka based firms for its population from which it sampled 381 firms. These were based on the 2010 Census by the Central Statistics Office.

[2]Accidental sampling, sometimes known as grab, convenience sampling or opportunity sampling, is a type of non-probability sampling that involves the sample being drawn from that part of the population that is close to hand (*Boxill et al., 1997)*. That is, a sample population selected because it is readily available and convenient, as researchers are drawing on relationships or networks to which they have easy access.

Various economic theories can be used to explain and analyse firms, as well as production in society. Key among the economic theories in manufacturing is the traditional production theory in microeconomics. Existing theories have highlighted the link between electricity use and production.

To empirically analyse the impact of load shedding on the productivity of firms in the manufacturing sector in Lusaka, we employ a variant of the Endogenous Growth Model. This is a simple extension of the Solow Model, allowing for constant growth through endogenously determined productivity. The model assumes that the rate of technological progress to be determined by a scientific process that is not separate from, and independent of, economic forces such as load shedding. The model starts from the observation that technological progress takes place through innovations, in the form of new products, processes and markets, many of which are the result of economic activities. For example, because firms learn from experience how to produce more efficiently, a higher pace of economic activity can raise the pace of processing innovation by giving firms more production experience.

Following the standard form of the Endogenous Growth Model, the Cobb-Douglas production function is given by

$$Y = AL^{\Theta}K^{\Omega} \quad (1)$$

where Y is total output, A is total factor productivity, L is labour input, K is capital input and Θ and Ω are output elasticities of labour and capital respectively.

The model for this study employs a variant of the Cobb-Douglas production function in (1) characterised as follows:

$$Y_i = AL_i^{\psi_1}K_i^{\psi_2}M_i^{\psi_3}E_i^{\psi_4}X_i^{\psi_5}(Own)_i^{\psi_6} \quad (2)$$

where Y_i refers to output of firm i, A is the total factor productivity, K_i is the stock of capital, L_i is the number of workers in each firm M_i is raw materials and intermediate goods used in production and is taken at cost; E_i is the impact of electricity load shedding and is measured using the electricity from alternative sources of power, particularly generators, when a firm is being load shed; X_i are the factors that come with firm's age which are associated with technical expertise in dealing with obstacles such as load shedding; and Own_i is the proportion of the firm owned by local shareholders in relation to the influence on productivity level of the firm and $\psi_i's, \forall\, i = 1,2,\cdots,6$ are output elasticities of the respective variables.

Since the TFP is defined as any change in output that is not due to changes in factor inputs we take a monotonic transformation of equation (2) to obtain the mathematical expression of the model as:

$$\ln Y_i = \psi_0 + \psi_1 \ln K_i + \psi_2 \ln L_i + \psi_3 \ln M_i + \psi_4 \ln E_i + \psi_5 \ln X_i + \psi_6 Own_i \quad (3)$$

where $\psi_0 = lnA$.

Adding the error term to equation (3), we can specify the econometric model for estimation purposes as follows:

$$\ln Y_i = \psi_0 + \psi_1 \ln K_i + \psi_2 \ln L_i + \psi_3 \ln M_i + \psi_4 \ln E_i + \psi_5 \ln X_i + \psi_6 Own_i + \xi_i \quad (4)$$

where $\xi_i \sim N(0,\sigma^2)$ is the error term measuring all other factors not explained by the model but have an influence on output measured using total annual sales and $\psi_i's, \forall\, i = 0,1,\cdots,6$ are parameters to be estimated.

Given the econometric specification, we calculate TFP to obtain estimates of the elasticities of output with respect to inputs and then treat TFP[3] as residuals from equation (4). Using this method, the prominent TFP related variable estimates would need to be regressed in the model to factors such as those related to power infrastructure that may have a direct bearing on the firm's productivity. These do not feature when estimating equation (1) but are clearly not random even though they are captured in the random error term and as such, they have been included directly into equation (4).

4. Model Estimation

Data Analysis

The data collected was analysed using the Gnu Regression, Econometrics and Time-series Library (Gretl) version 1.9.8 software package and STATA version 13. The data was also grouped in particular instances to allow for comparative analysis of the various variables, including those that may not be part of the model but provide an insight into the implication of load shedding on manufacturing.

The results of the study were estimated using the method of ordinary least squares (OLS). Table 4 presents results for the model estimated.

Table 4: Ordinary least square (OLS) Model results Dependent variable: LnY

Sum squared residuals	**114.6951**	**S.E. of regression**	**1.596490**
R-squared	0.973432	Adjusted R-squared	0.969889
F(6, 45)	274.7905	P-value(F)	9.66e-34***
Log-likelihood	−94.35168	Akaike criterion	202.7034
Schwarz criterion	216.3621	Hannan-Quinn	207.9398

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
Const	1.10447	1.15192	0.9588	0.3428	
LnL	0.523461	0.0809003	6.4704	<0.0001	***
LnK	0.0944444	0.0243651	3.8762	0.0003	***
LnM	0.394352	0.0651682	6.0513	<0.0001	***
LnE	-0.189216	0.0876247	-2.1594	0.0362	**
LnX	0.424161	0.132864	3.1924	0.0026	***
Own	0.00185488	0.00180244	1.0291	0.3089	

Standard errors reported as absolute values, **Significant at 5% level; *** significant at 1% level;

Results indicated that 97.34% of the variations in the total annual sales, the dependent variable measuring productivity

[3] Recall that TFP is the portion of output not explained by the amounts of inputs used in production and its aim is to identify output differences that cannot be explained by input differences at country or firm level. TFP is measured at country level using the Solow residual while at firm level; this can be estimated using a number of approaches, such as index numbers or data envelope analysis, as well as parametric methods, like stochastic frontiers.

of the firm, is explained by the model indicating a very good fit for the model. The model is also significant at all levels of significance. This is supported by the high adjusted coefficient of determination which is the appropriate measure of the correlation accounting for the presence of multiple independent variables, which is also very high.
Results reveal that, all things being equal, a 1% increase in labour input results in about 0.52346% increase in total annual sales. Similarly, a 1% increase in capital, on average, results in a 0.09444% increase in total annual sales of a firm in the manufacturing sector in Lusaka. In like manner, a 1% increase in raw materials and intermediate goods on average results in a 0.39435% increase in total annual sales of a firm. However, with regard to our variable of interest, electricity load shedding, vis-à-vis the amount of power used from generators, a percentage increase yields a 0.18922% decrease in annual sales of a firm in the manufacturing sector, ceteris paribus.
That notwithstanding, a percentage increase in capacity factors associated with firm age result in a 0.42416% increase in total annual sales. All these results were found to be highly significant implying that labour, capital, raw materials and intermediate goods, load shedding and age of the firm are important predictors of firms' productivity in the manufacturing sector in Lusaka.
An increase in the percentage of local shareholding in a firm by 1% point results in about 0.00185% increase in annual sales but was found to be statistically insignificant. This means that the percentage of local shareholding in a firm is not important in determining the level of productivity of a firm in the manufacturing sector in Lusaka. However, this does not necessarily dispute the literature that suggested that foreign firm ownership increases firm productivity. This is because, in some instances, the percentage of local firm ownership may be held by a Government entity which may provide the same technical expertise and resources that come with foreign ownership.

Sub-Sector Analysis
A further analysis of the variable of interest was done to ascertain the impact of electricity load shading on the different sub manufacturing sectors. The results were as reported in Table 5.

Table 5: Sub-Sector Analysis of load shedding

Sub-Sector	Variable of Interest	Coefficient	std. error	t-ratio	p-value
Food	LnE	−1.9021	0.3101	-6.1330	0.0003 ***
Furniture and Wood Processing	LnE	−0.1112	0.9318	−0.1193	0.9077
Metal Fabrication	LnE	−1.4218	0.2238	−6.3540	0.0031 ***
Garments and Leather	LnE	−2.5660	2.4675	−1.0400	0.3571
Non-Metallic Minerals	LnE	−0.5726	0.2820	−2.0300	0.1353

At sub-sector level, all things being equal, power outages have a negative effect in all the sub-sectors and this effect is significant at all levels in the food and metal fabrication sub-sectors, while insignificant in the furniture and wood processing, garment and leather, as well as the non-metallic minerals sub-sector.
The significant effect on the two sub-sectors could partly be due to the sensitivity of the production processes where disruption of power during production may adversely affect the quality of output or indeed result in damages. In addition, the equipment used in these two sub-sectors may also be power intensive as compared to the others. It should, however, be noted that not all the processes in the other sectors where the effect is insignificant, such as garment and leather, rely entirely on machinery use as some of the components are handmade, while some equipment is operated by hand.

5. Discussion
From the analysis of the study, it can be seen that load shedding has a negative and significant impact on the manufacturing sector in Lusaka. This finding is supported by (Sing'andu, 2009 and Mayer-Tasch *et al*., 2009) [22] indicating that manufacturing firms on average rely on energy, particularly electricity, as a key input in the production processes. As such, even the cost of this input is set in the firms' planning based on the source and previous expenses, and in some instances, on the targeted level of output.
The argument is that power is an intermediate input and any reduction in its costs raises the profitability of production and enhances the marginal productivity of labour and capital (Kessides, 1993) [13]. It cannot be overemphasised that the disruptions and related costs with which loss of power brings with it are an integral component of any firm's operational makeup (Van Der Nest, 2015). In the absence of regular supply of electricity, even when it is pre-arranged with the supplier as is the case in Zambia; firms incur higher costs on alternative sources of energy which is mainly generators. In fact, Park *et al*. (2014) [20] found that it is costlier to operate a plant on a generator than it is from conventional power supply. This is attributed to the increased maintenance cost of the generator, as well as the cost of fuel required to run it for the firm to operate at the required level. In the analysis of this study, it can be seen that there is an inverse relationship between the percentage loss of annual sales due to load shedding and the percentage of power from a generator for operations.
The World Bank (2014) also supports that some firms would switch to generator power at the start of a particular production process when they know that there would be load shedding during a particular run that does not require interruption when switching from conventional to alternative sources. This justifies the use of power from a generator to measure the impact of load shedding than say, duration and frequency of power outages. In some instances, firms, especially the larger and more established ones, reported an inconsequential impact on their operations which was sometimes positive, notwithstanding the insignificance.

Meanwhile, it can also be noted that there are other factors in a firm that might render load shedding insignificant. This is because in order to avoid the adverse effects of power outages, many firms have developed coping strategies consisting of generating their own electricity by means of owning, sharing, or renting a generator, or else by self-production of electricity. For instance, some firms may not see power outages as a hindrance but instead as opportunity to dominate the market at the expense of those firms that might be faltering. In this regard, firms may decide to invest more in mitigating measures against power loss with a view to increasing production on the assumption that some firms will slow production. On the other hand, new firms may enter the market at a time that there is increased load shedding and would have already made the necessary provisions for it at a time when the competitors are struggling to make provisions. This may give an upper hand to the new entrants as they will almost not be affected by the outages.

6. Conclusion

It cannot be overemphasised that electricity is a key input in the production process as even other inputs, especially machinery and equipment, rely on it to run. Controlling for other variables, the study has also shown us that load shedding has a negative and significant impact on productivity. That notwithstanding, firms, depending on various factors, adjust and cope differently by, among other means, investing in long-term alternative power sources. However cost implications should carefully be analysed in order to avoid cost overruns and ultimately threatening the life of the firm.

From the study undertaken, it is clear that Zambia needs to diversify from hydropower to alternative sources of energy. Since the current power shortage has been attributed to poor rainfall patterns, majority stakeholders hold the view that continued reliance on hydropower will make the country remain susceptible to the impact of climate change on power generation. As a result, several stakeholders and energy experts have recommended that further investment should be made in solar power and thermal energy. On the manufacturing sector, its importance to economic growth cannot be overemphasised and as such, all factors that affect it negatively need to be addressed by all concerned parties vis-à-vis the Government and the firms themselves.

The Government needs to provide incentives to manufacturing firms such as reducing or totally eliminating duty on industrial generators, especially for small and medium enterprises in order to promote growth in the sector in the short term. In the absence of a better quality supply, ZESCO Limited must also providing reliable load shedding schedules. This would enable them to plan production around outages. In order to provide load shedding schedules, it may be necessary to focus on reducing technical faults in existing transmission and distribution infrastructure as a short-term priority over the long-term necessity to increase generation capacity.

Further, the Government should seriously consider the longstanding call and recommendation for ZESCO Limited to be unbundled into three separate entities, namely generation, transmission and distribution. In doing so, private partners and players may be brought in generation and distribution, while transmission can be left to the State entity. This notion has been moved before by other studies, including Nsupila and Chimfwembe (2015) [19] stating that unbundling will improve the quality of service delivery, reduce bureaucracy and inefficiency, reduce the staffing levels and costs associated with staffing and promote private sector participation among other things.

7. Limitations

The impact of load shedding on the profitability of firms could not be ascertained as majority of firms in the population of the study were reluctant to disclose their profits during the World Bank Enterprise Survey (2014) [24]. This was attributed to perceived fears that the information could be used by other users, including Zambia Revenue Authority (ZRA), as a basis to collect taxes from them. Forster *et al*. (2008) adds that some firms are sceptic about sharing their profits margins with competitors, while others merely want to under declare profits with a view to avoiding paying the necessary taxes.

In addition, the variables used in the study contain information from the sampling frame from the World Bank Enterprise Survey (2014) [24] and as such may not reflect the reality of individual establishments because some of the information may be incomplete. However, the non-probability sampling approach attempted to minimise the problems that the sampling frame posed as the technique endeavoured to ensure that only firms with complete information regarding the key variables were picked. These firms also represented the major sub-sectors. Besides, there is no other survey that collects such type of information on Zambia's manufacturing sector.

8. Areas for Further Study

Further studies may be done with profitability of the firm being the dependent variable as this would give a clearer insight into the real impact of electricity load shedding on firm welfare in the manufacturing sector. This is because traditionally, profit maximisation is assumed to be the sole objective of business firms and has a great predictive power. Longitudinal data may also be used to give a more robust interpretation on the relationship between the variables of interest.

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