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Technical Efficiency and Capacity Utilization of Manufacturing Small and Medium Scale Enterprises in Zambia

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Abstract:

Small and medium scale manufacturing has been identified as a key driver of wealth and employment creation in Zambia. This study analyses the technical efficiency and capacity utilisation of small medium enterprises (SMEs) manufacturing firms in Zambia using the data envelope analysis (DEA) approach. Firm-level data on inputs and outputs were obtained from the Zambia Revenue Authority (ZRA) for 77 firms that fit our criteria of SMEs for the year 2019. The empirical results reveal that the overall average technical efficiency is relatively low, which can potentially reduce their output contribution. Estimates of relative technical efficiency suggest that SMEs in this industry can, on average, produce the same level of output using approximately 28 percent less inputs. Estimates of relative cost efficiency suggest that SMEs can, on average, realise cost savings in the order of 32 percent by reducing both the level and mix of inputs. The findings also show that SMEs operated at significantly less than full plant capacity, indicating that constraints on variable inputs inhibit production to at least 25 percent. Policies are required to improve the technical efficiency of SMEs that include easier access to credit facilities and international markets. Further, there is a need for extensive infrastructure development and technological upgrading, marketing and management.

JEL classification: E60, D24, O40
Key words: Efficiency; capacity utilisation, manufacturing, data envelopment analysis.

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Contents

1. Introduction

Manufacturing is an important sector in the Zambian economy for several reasons. Firstly, it is the hub of value addition, which is crucial for generating growth opportunities. Manufacturing is key to ensuring that Zambia can transform its economy towards more formalised jobs and reduce dependence on low productivity informal sector jobs. Secondly, manufacturing is important for the creation of gainful employment opportunities. In 2020, the projected employment from new investment and re-investment projects was concentrated in the manufacturing sector which accounted for 53 percent of this projected employment (Zambia Development Agency, 2020). The actualised employment for 2020 was highest in the manufacturing sector that accounted for 43.4 percent of jobs created. Manufacturing is also important for linkages to agriculture and other primary sectors. Specifically, manufacturing growth offers prospects for structural growth into high productivity areas rather than economic growth driven by the exploitation and export of raw commodities or natural resources. Thirdly, productive inefficiency has been blamed for failure of economies not only in Zambia, but across sub-Saharan Africa (SSA) to industrialise in the face of global trade liberation (Chansa et al, 2019). Inefficient local firms are simply unable to compete with more efficient foreign firms. Consequently, firm closures have led to de-industrialisation across SSA, turning the continent into a dumping ground for foreign goods and a home to low productivity trading as a main source of economic livelihood. Zambia has experienced her fair share of these challenges (Chansa et al, 2019). Finally, the manufacturing sector is key in domestic resource mobilisation when firms are tax compliant and also in the quest for import substitution which can help improve the country's balance of payments position.

However, manufacturing remains under-developed in much of SSA. Operating inefficiency and low productivity are major constraints to growth in manufacturing in SSA (Gelb et al. 2014). In Zambia, the manufacturing sector has come under considerable pressure. Competition from global and regional firms, sluggish macroeconomic environment, and limited knowhow all constrain performance (UNIDO, 2020; Osakwe, 2021). However, not much attention has been paid to the investigation of the operational efficiency of manufacturing small and medium enterprises (SMEs). Indeed, studies on measuring efficiency remain patchy. In Zambia, there has been no formal empirical analysis of operating efficiency of small-scale manufacturing firms. This is despite the importance that government attaches to manufacturing as a driver of economic output, economic diversification and employment creation and poverty reduction. This study seeks to fill this gap.

SMEs constitute a major proportion of all firms in Zambia and elsewhere in SSA. They are also a focus of policy attention in relation to employment creation and poverty alleviation. The projected employment for micro, small and medium enterprises (MSMEs) between 2019 and 2020 increased by 1.6 percent (Zambia Development Agency, 2020). MSMEs are believed to deepen the manufacturing sector as they encourage competitiveness and help in achieving a more equitable distribution of the benefits of economic growth (Ministry of Commerce, Trade and Industry, 2008).

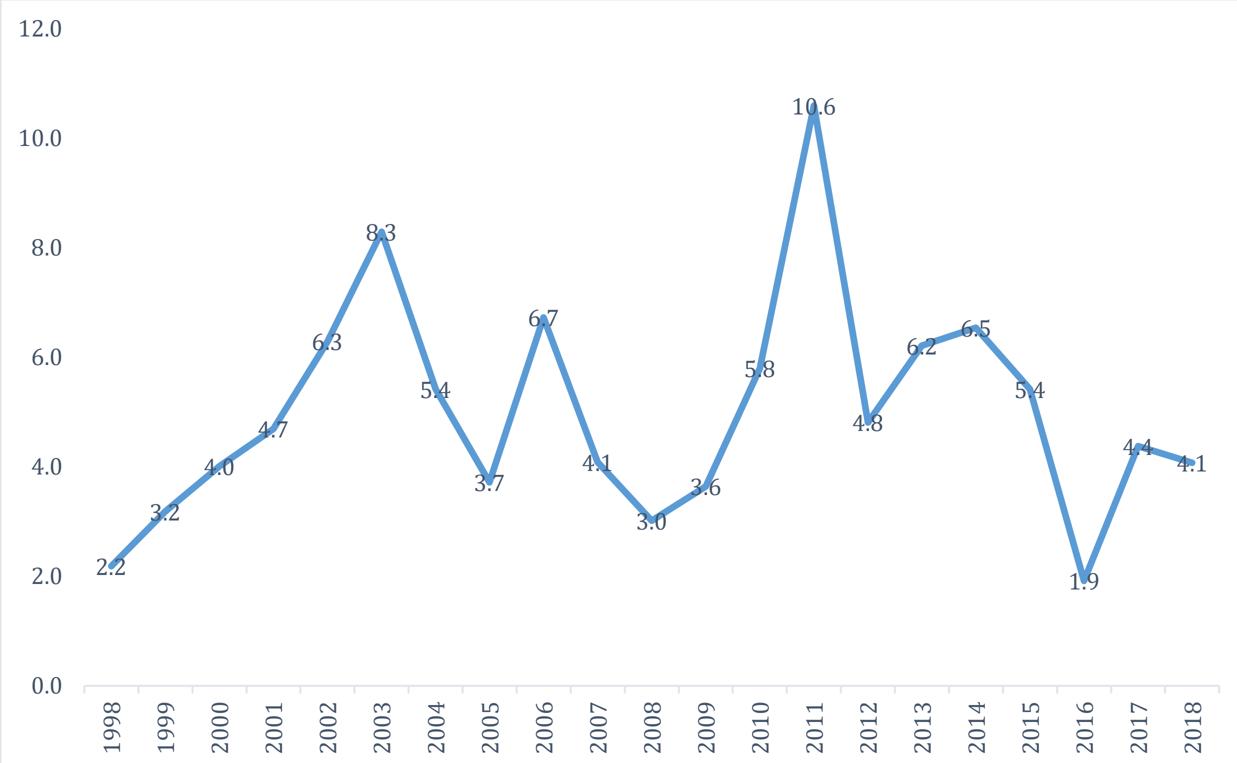
Within the MSMEs sector in Zambia, manufacturing activities account for 41 percent of all activities. The main purpose of this study is to estimate the technical efficiency of manufacturing SMEs in Zambia. The findings from the study indicate that manufacturing SMEs in Zambia operate at relatively low levels of efficiency at only 76 percent. In addition, installed plant capacity among manufacturing SMEs is under-utilised, suggesting waste of capital assets. Findings from this study will help managers of these firms to examine their operational performance in terms of efficient utilisation of their resources and production capacities. Firms could adopt the practices of more efficient firms included in the analysis. Empirical evidence on technical efficiency could also help the government to formulate policies to further support the manufacturing SMEs to improve their operating efficiency.

The rest of the paper is organised as follows. Section 2 discusses trends in manufacturing growth rates while section 3 reviews the relevant literature. Model specification and estimation method are presented in section 4. Data sources and description are contained in section 5. Section 6 presents and discusses empirical results. Section 7 concludes.

2. Trends in Manufacturing Growth Rate, 1998-2018

In 2018, the manufacturing sector in Zambia accounted for about 8.1 percent of the country's gross domestic product (GDP) which was half the average of other low and middle income countries (UNIDO, 2020). Growth in the manufacturing sector has largely been driven by the agro processing (food and beverages), textiles and leather subsectors. Secondary processing of metals is another main activity in the sector, including the smelting and refining of copper. Fertilisers, chemicals, explosives and construction materials such as cement are also produced in the sector. Figure 1 shows the growth trend in the manufacturing sector over a 20-year period from 1998 to 2018.

Figure 1: Trends in Total Manufacturing Growth



Source: Authors' own computations

The performance of the sector between 1998 and 2018 was positive but volatile. The sector experienced an upward growth from 1998 till around 2003 reaching 8.3 percent, thereafter started experiencing downward trends till it reached around 3.7 percent in 2005. The growth of the sector between 2010 and 2011 was upward before it experienced another downward trend and the lowest growth being registered in 2016. There was slow growth in the sector from around 2014 to 2016 due to some constraints such as electricity shortages occasioned by the drought and high production costs which contributed to the drop in output of between 60 percent and 70 percent (Ministry of National Development Planning, 2017).

According to the Seventh National Development Plan (2017-2021), Zambia's manufacturing sector grew at an average annual growth rate of 3 percent between 2006 and 2015. Further, the 2005 and 2020 Labour Force Survey (LFS) showed that there were 166,143 persons employed in the manufacturing sector in 2005, which increased to 252,075 in 2020. Based on the 2020 LFS, of those employed in the manufacturing sector, 29.7 percent were in the rural area while 70.3 percent were in the urban area. Apart from this, the sector is affected by the performance of other sectors. Notable sectors with strong linkages to the manufacturing sector include the agriculture and electricity sectors. Reduced agricultural output and constrained power supply adversely affected the manufacturing sector as observed through the lower growth in the first three quarters of 2019 of 3 percent compared to that of 2018 which stood at 5 percent (Ministry of Finance, 2019).

3. Literature Review

The performance of the manufacturing firms continues to be of interest in various countries. Tingum and Ofeh (2017) considered the determinants of efficiency for manufacturing firms in Cameroon using the stochastic frontier model. The study discovers that firm size, foreign ownership, corruption and age of the firm affect efficiency of the firms. Large firms reduce efficiency while foreign ownership increase efficiency. Large firms face higher relative labour costs compared to small firms. Their findings on large firms is similar to the result obtained by Söderbom and Teal (2002) who investigated the performance of manufacturing firms in Ghana. Their findings show that foreign ownership does not lower technical inefficiency, and that observable skills are not important in determining productivity. Similar to the findings on firm size, Edjigu (2016), in analysing firm growth and efficiency of manufacturing firms in Ethiopia, finds that small and young firms tend to grow faster than large and old firms. This is similar to the findings by Ahmed and Ahmed (2013) who considered a case study of seafood processing firms in analysing efficiency variation of firms in Bangladesh. Using a stochastic frontier model, the study findings also show that younger and smaller firms enjoy higher production efficiency than larger and older firms.

Meanwhile, Smriti and Khan (2021), in looking at the performance of manufacturing firms in Bangladeshi using the 2013 World Bank enterprises survey, discovered that firm size, managers' experience, annual losses due to power outage, and the number of production workers play a role in improving efficiency. Linn and Maenhout (2019) consider profitability and efficiency in rice production in Myanmar. Using the data envelopment analysis (DEA), the study discovers that farmers can improve their yield by improving input utilisation. Technical inefficiency is caused by excessive use of inputs while allocative and economic inefficiencies are as a result of the wrong combinations of input usage. Nasir et al. (2018) consider the efficiency of the manufacturing sector in the Province of Aceh in Indonesia using the DEA. The findings show that efficiency is seen in the steel, food and tobacco and chemical, fertilizer and rubber manufacturing sub-sectors under variable returns to scale. Smriti and Khan (2021) point out that whether constant returns to scale or variable returns to scale, the comparison of efficiency of all manufacturing sectors results in relatively the same efficiency scores.

4. Model Specification and Estimation Method

An input-oriented model of technical efficiency—DEA—is adopted in this study. The DEA model of technical efficiency is a measure of departure from maximum feasible output from available inputs based on the ratio of inputs to outputs. In other words, an inefficient firm could be made efficient by the proportional reduction of its inputs while the proportions of its outputs are held constant. Conceptually, this model defines technical efficiency as the radial or proportional reduction of a firm's inputs for a given output set. Thus, the inputs are the choice variables of the firm — the corresponding output-oriented alternative specification measures the extent of output expansion while inputs are held constant. The DEA approach to technical efficiency analysis is particularly useful because of its feasibility of using multiple outputs.

The model is presented formally by assuming that there are j firms (or decision-making units, DMUs) in an industry producing m outputs denoted by u using n inputs denoted by x. Each firm produces at least some outputs i.e. $u^j \succ 0$ and $x^j \succ 0$.

The Fare, Groskopf and Lovell (FGL) measure of technical efficiency, which shows the maximum feasible output that can be produced using observed inputs, is derived by solving the following linear programming problem:

$$Min \ \theta_1$$

s.t.:

$$\theta_1 u_{jm} \le \sum_{j=1}^{J} z_j u_{jm} , \ \text{j=1,2,…,J} \qquad (1)$$

$$\sum_{j=1}^{n} z_j x_{jn} \le x_{jn} , \ n \in x$$

$$z_j \ge 0$$

where the second constraint in the model indicates that observed values of inputs are the upper bounds. They z_j are called intensity variables which serve to connect the observed input-output points to construct the piece-wise linear frontier of best practice DMUs against which the technical efficiency of each DMU is measured. The intensity variables indicate the necessary combinations of efficient or reference DMUs (peers) for every inefficient DMU. They are also defined as weights given to each observation relative to which the optimal input-output point is being compared. In this model, the restriction imposed on the intensity variables is that they are non-negative, which is the requirement for our assumption of a constant returns to scale technology. We estimate our technical efficiency using variable returns-to-scale (VRS) as well as constant-returns-to-scale (CRS) technology. CRS is a more stringent assumption given that the ability of the firm to change capital such as plant and machinery is only feasible in the long-run. The equation estimates a series of j programming problems, one for each DMU, yielding the optimal solution of maximum output for each DMU. To change the assumption to VRS, a convexity assumption is needed on intensity variables in equation (1): $\sum_{j=1}^{n} z_j = 1$.

In addition to technical efficiency, we measure firms' level of capacity utilization (CU). The DEA-based framework for measuring capacity utilisation follows Fare, Groskopf and Lovell (1985). The FGL model applied Johansen's definition of capacity utilization as the ratio of actual output to potential output. Potential output is the maximum feasible output assuming that there are no restrictions on the level of variable inputs given the fixed factors. It is a measure of how much more output can be produced if available capital or plant capacity is employed to full capacity. Analytically, the FGL model calculates the ratio of the maximum output from observed inputs (equivalent to the observed technically efficient level of output) to the maximum capacity output when variable inputs are not bound by observed values but allowed to vary without restriction. For example, while a firm's capital can be fixed in the short-term, its working capital (raw materials, utilities, personnel cost and administration) can be allowed to vary without constraints.

Inputs are partitioned into two sub-vectors of fixed (values constrained by observed values) and variable (values unconstrained by observed values) inputs. Thus, $u^j \in R_+^M$ $x^j \in R_+^N$ and $x^j = (x_F^j, x_V^j)$. Each firm produces at least some outputs, i.e. $u^j \succ 0$ and $x^j \succ 0$.

We take the technical efficiency scores given by θ_1 as above. We then estimate a model in which we assume that some fixed inputs are given by their observed values while the variable inputs can vary without restriction. The corresponding linear programming model that we solve is given as:

$$Max\ \theta_2$$

s.t.:

$$\theta_2 u_{jm} \le \sum_{j=1}^{J} z_j u_{jm}\ ,\ \text{j=1,2,…,J} \qquad (2)$$

$$\sum_{j=1}^{n} z_j x_{jn} \le x_{jn}\ ,\ n \in x^F$$

$$\sum_{j=1}^{n} z_j x_{jn} = \lambda_{jn} x_{jn}\ ,\ n \in x_V$$

$$\lambda_{jn} \ge 0$$

$$z_j \ge 0$$

where z_j is the intensity variable for the j^{th} firm as defined earlier. The parameter λ_j is the utilisation rate of input n for each firm. The second constraint shows that the observed input values are bound by their observed values. The third constraint as well as the condition on λ_j is intended to make the variable inputs not to be constrained by their observed values. The optimal value of λ_{jn} is then determined as the level of utilization of input n that is compatible with full capacity utilisation of firm j. Again we assume constant returns to scale technology.

Based on the above, our measure of technically efficient capacity utilisation is then given by

$$CU = \frac{\theta_1}{\theta 2} \le 1$$

where CU < 1 represents under-utilisation of fixed inputs (i.e. an excess of fixed inputs), and CU =1 depicts a full utilisation of the available fixed inputs. Thus, the FGL approach to CU measurement shows departures from full capacity output consistent with full utilisation of inputs and also accounting for any technically inefficient production given observed inputs.

We estimate an input-oriented —hold the firm's observed output level fixed —short run measure of firm technical efficiency using the VRS (variable returns to scale) and the CRS (constant returns to scale) models. Further, we estimate the level of capacity utilisation of each firm with a view to estimating the impact of constraints on operating capital on the firm's production. In this case, we hold capital fixed but allow other variable inputs to change without restrictions. Additional analysis include scale economies. We generate a technical efficiency score for each firm. Descriptive statistics are used to present the results. All estimations were run using On-front software.

5. Data Sources and Description

The used data is based on a sample of 77 SMEs in the manufacturing sector in Zambia for the year 2019. This data was obtained from the Zambia Revenue Authority (ZRA) and the categorisation of the sub-sectors was done according to the International Standard Industrial Classification (ISIC). The sub-sectors included are food and beverages, chemical, rubber and plastic products and fabricated metal, wood and wood products consisting of 40 percent, 33 percent and 27 percent of firms, respectively.

Input variables collected for these firms include the number of employees (to capture human resource), operating expenses (in Kwacha) and capital costs (proxied by capital allowance). The output variables include gross sales and gross profit (both in Kwacha). Table 1 provides a description of these variables.

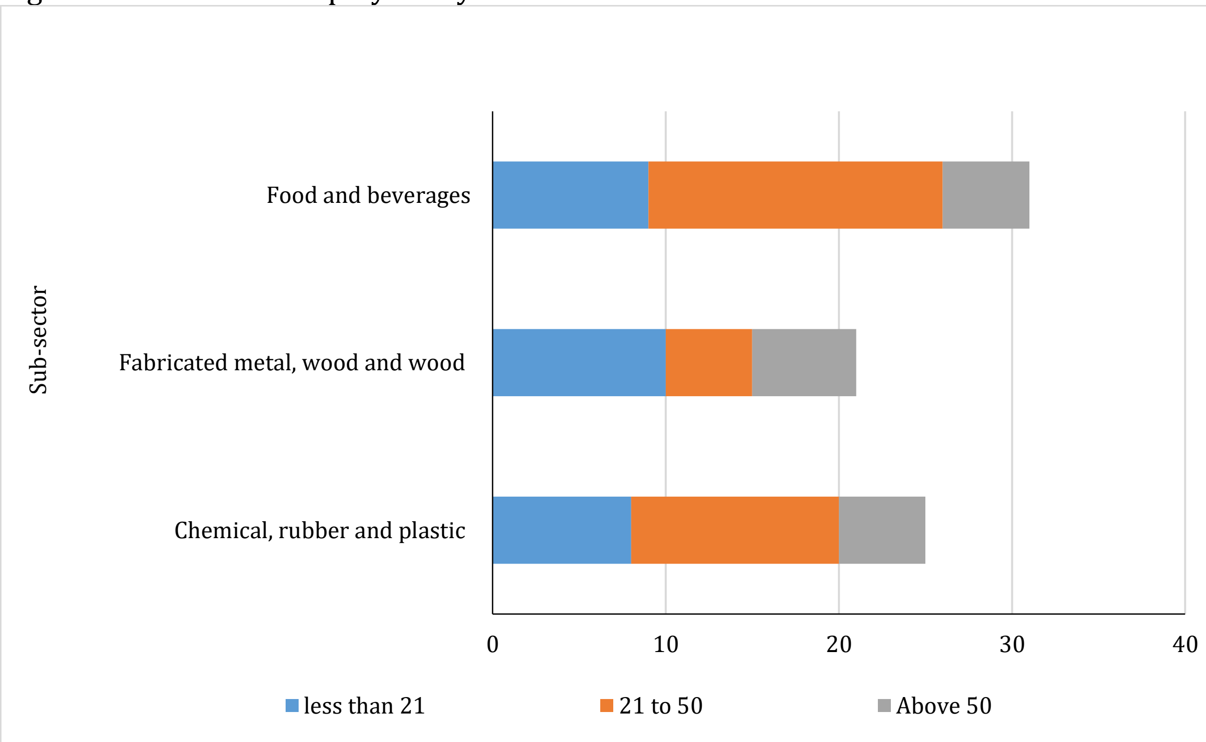
Table 1: Description of Variables

Variables	Mean	Minimum	Maximum
Employees	36	11	99
Gross sales	16,800,000	345,372	121,000,000
Gross profit	3,700,616	-926,807	32,600,000
Operating expenses	1,653,620	29,271	11,500,000
Capital allowance	972,124	2,063	9,496,927

Source: Authors' own computations

The average gross sales are K16.8 million while the average gross profits are approximately K3.7 million. Average operating expenses are approximately K1.7 million. The average capital allowance is approximately K0.97 million with the lowest being K 0.002 million and the highest being approximately K 9.5 million. The firms employ between 11 to 100 fulltime employees. A look at employees by sub-sector shows that most firms in the food and beverages and the chemical, rubber and plastic sub-sectors employ between 21 and 50 employees. The fabricated metal, wood and wood sub-sector mostly employs between 11 and 20 employees. This is as shown in Figure 2.

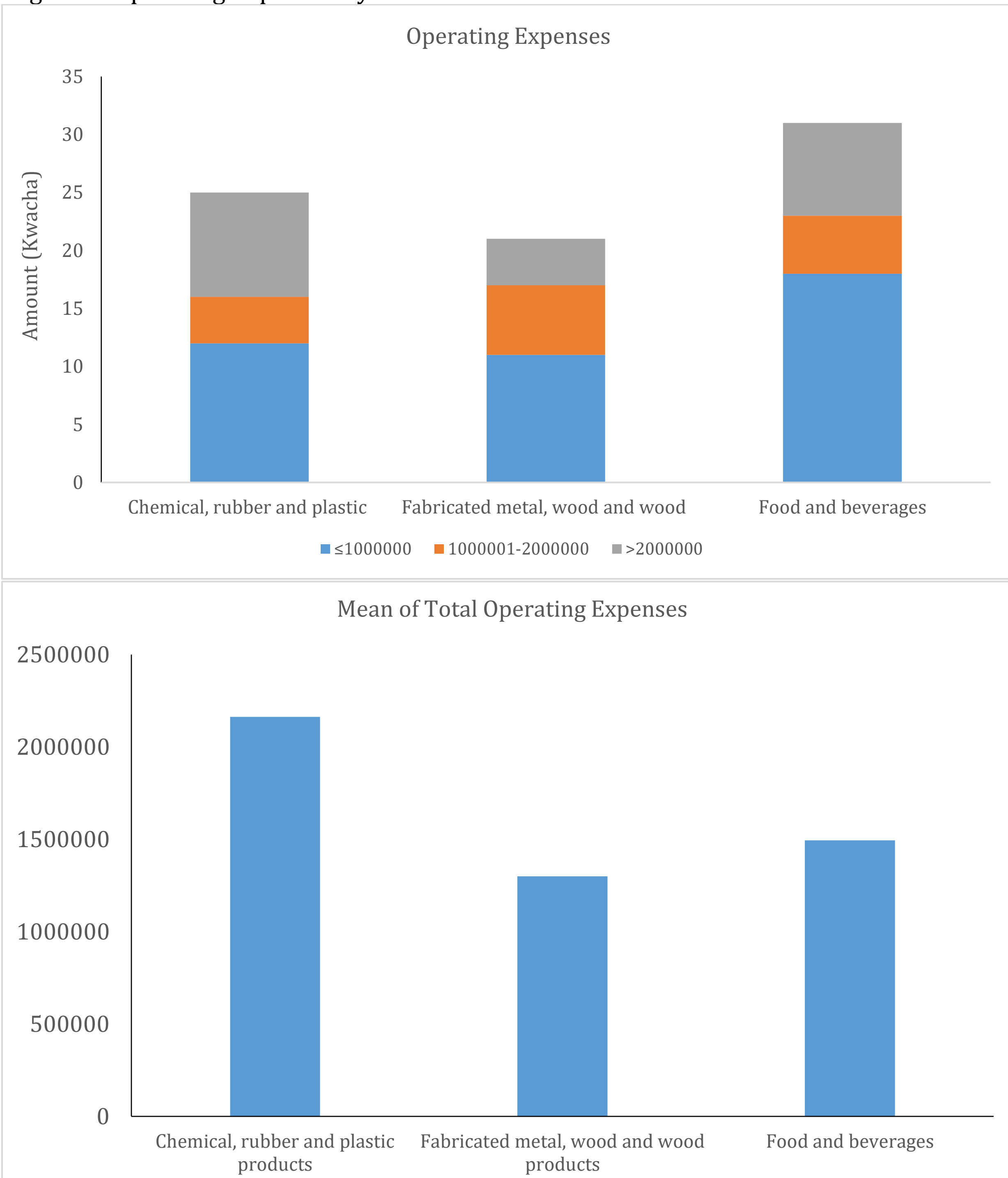
Figure 2: Number of Employees by Sub-sector



Source: Authors' own computations

In terms of operating expenses, most firms in the sub-sectors had an operating cost of less than or equal to K10 million. This constituted 48% of the firms in the food and beverage sub-sector while for the fabricated metal, wood and wood products and the chemical, rubber and plastic products sub-sectors, this constituted 52 percent and 58 percent of firms, respectively. This can be seen in Figure 3.

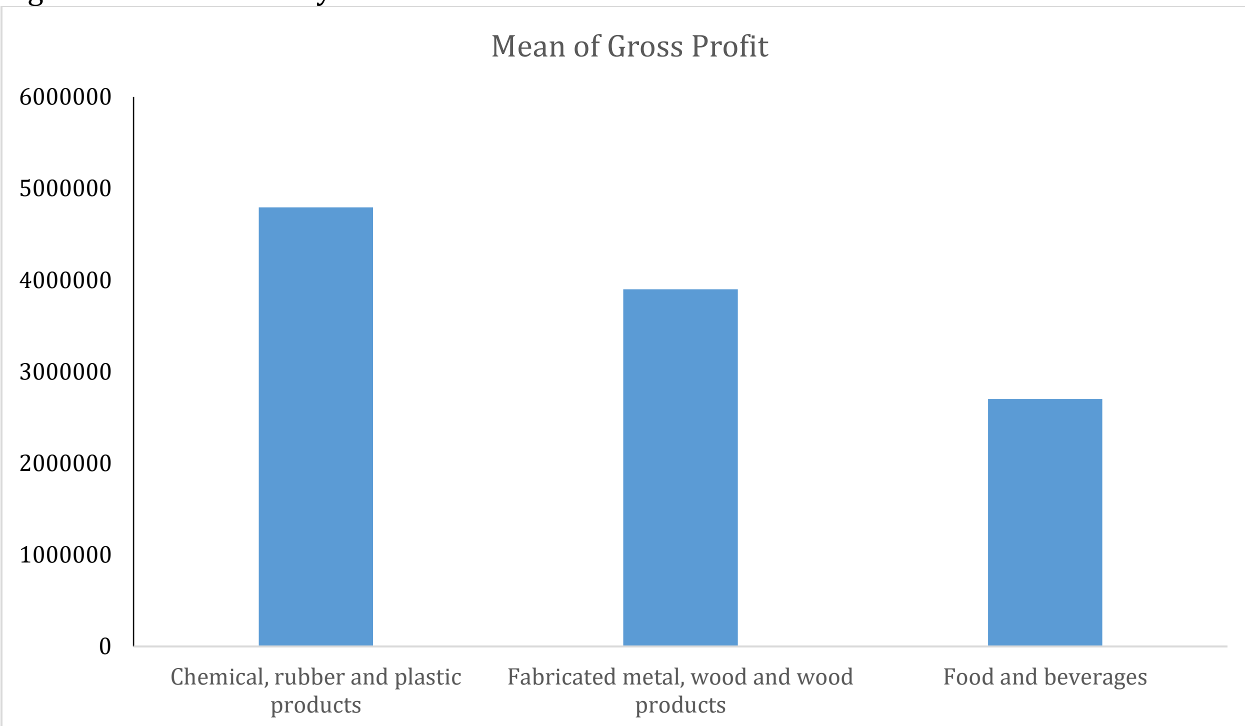
Figure 3: Operating Expenses by Sub-sector



Source: Authors' own computations

Figure 3 also shows that the average operating expenses are greater in the chemical, rubber and plastic products sub-sector followed by the food and beverages sub-sector. In terms of gross profits, Figure 4 shows that the average gross profits were higher in the chemical, rubber and plastic products sub-sector followed by the fabricated metal, wood and wood products sub-sector.

Figure 4: Gross Profit by Sub-sector



Source: Authors' own computations

6. Empirical Results and Discussion

The first set of empirical estimates of technical efficiency of SME manufacturing firms are reported in Table 2.

Table 2: Summary VRS Technical Efficiency results

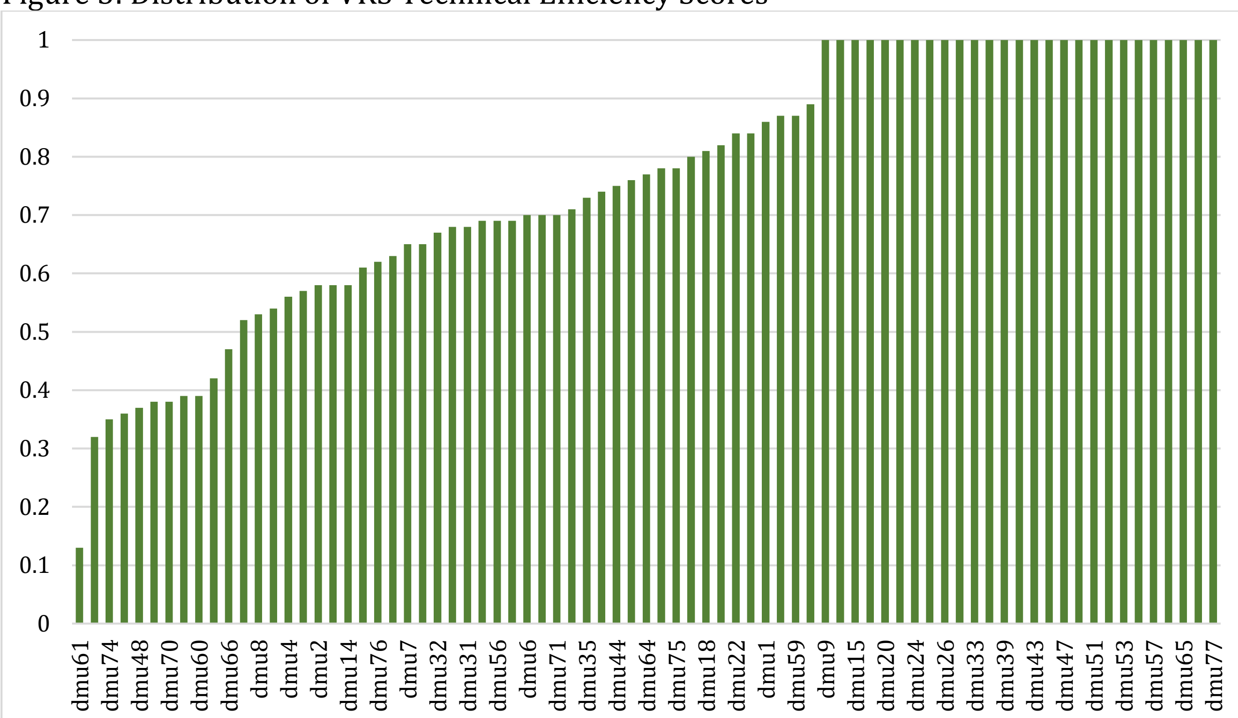
Mean	0.758
Standard deviation	0.228
Median	0.77
Skewness	-0.549
Kurtosis	2.37
Number of Obs.	77

Source: Authors' own computation

Under CRS assumption, average technical efficiency was estimated at 60 percent. If we assume the more flexible VRS production technology, the mean technical efficiency score was 76 percent. These results suggest the presence of significant input slack. These findings demonstrate that, on average, manufacturing SME firms could produce the same level of outputs with 24-40 percent less inputs.

Further, the distribution of technical efficiency among firms varies widely, ranging from 13 percent to 100 percent under VRS. About 35 percent of the firms operated at full efficiency while 15 percent of them in the sample were operating at less than 50 percent level of efficiency. Under the CRS measure (a more restrictive assumption of technology) about 40 percent of SMEs have efficiency of more than 80 percent. The skewness statistic shows only a slight leaning to the right of the mean, and can be confirmed in the histogram in Figure 5 where there are more observations to the right of the mean.

Figure 5: Distribution of VRS Technical Efficiency Scores



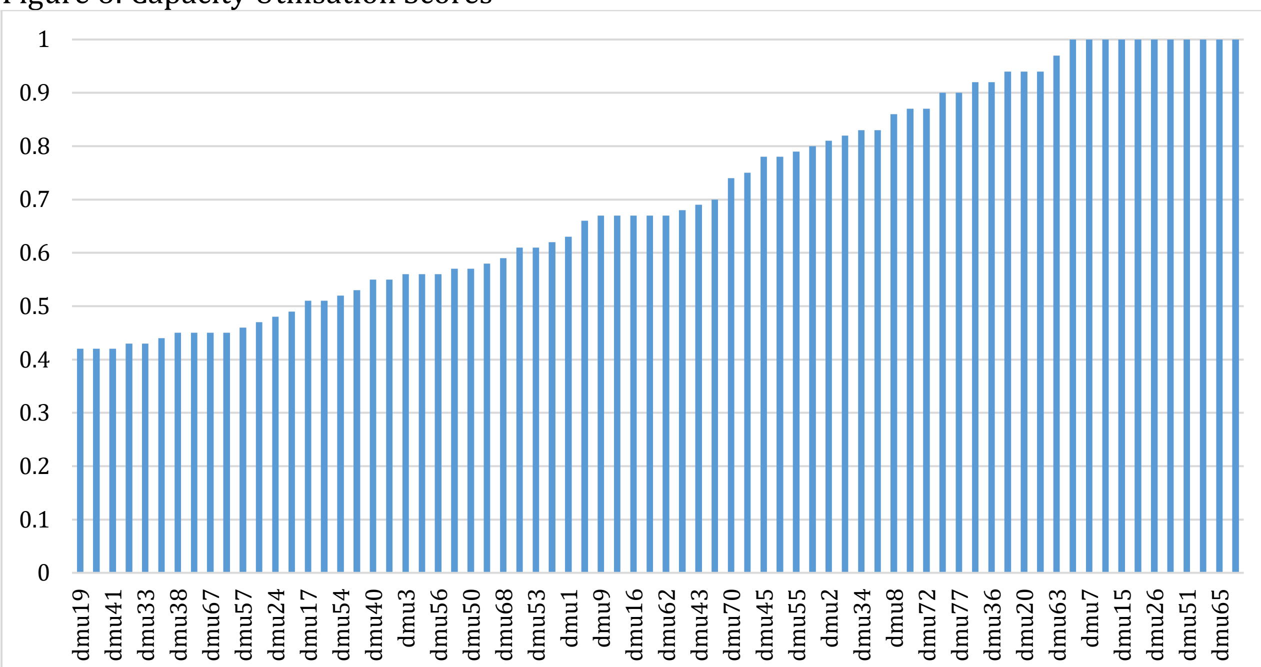
Source: Authors' own computations

Manufacturing efficiency is an important determinant of the ability of Zambian firms to survive in the face of increasing exposure to international or regional competition. Increases in firm productivity is also an important policy objective to ensure long-term economic growth. The results show that average technical efficiency is quite low at 76 percent (median at 77 percent), suggesting under-significant performance. Further, the distribution shows skewness towards very low levels of technical efficiency. There is significant heterogeneity in the level of technical efficiency across SMEs in Zambia. Future research should focus on examining the determinants of technical efficiency.

The literature highlights a number of factors that affect manufacturing efficiency, including firm type, firm size, energy costs, fluctuations in demand, exchange rate fluctuations and high import costs, and the policy environment. Studies in Africa have demonstrated that manufacturing firms operate under significant inefficiency. The average level of technical efficiency reported in this study is comparable to what other studies have reported (Cheruiyot, 2017). Studies in Kenya showed that smaller manufacturing firms were more efficient than bigger firms (Ngui and Muniu, 2012; Haron and Chellakumar, 2012; Edjigu, 2016).

Summary statistics of capacity utilisation of SMEs show that there is significant under-utilisation of plant capacity among firms. Only 15 percent of firms were operating at full capacity. The mean capacity utilisation score of 70 percent shows that firms face challenges of producing at full capacity of the plant. The distribution of capacity utilisation scores in Figure 6 demonstrates that capacity ranges from a low of 42 percent to full utilisation.

Figure 6: Capacity Utilisation Scores



Source: Authors' own computations

7. Conclusion

This study has found that manufacturing SMEs in Zambia operate at relatively low levels of efficiency at only 76 percent. In other words, the study highlights that same level of output can be obtained by reducing the inputs by 24 percent. Further, installed plant capacity is under-utilised suggesting waste of capital assets. Inefficiency undermines value addition, firm competitiveness, and employment creation. If not adequately addressed, this will limit the expected role of SMEs in the manufacturing sector. In efforts to diversify the economy, the potential of SMEs in creating employment and alleviating poverty has been highlighted. To ensure that this potential is achieved, SMEs in the manufacturing sector will require that efficiency be improved. This was an exploratory study. As more years of data are made available, it would be important that a study on productivity and technical change over time is conducted.

A number of limitations are worth pointing out. The study lacked data on key firm-level characteristics. Such characteristics include firm management quality, years of experience, ownership type and location, among others. A better data set, which would allow identification of firm-level characteristics would sharpen our understanding of efficiency and its determinants. The study also uses only cross-sectional data for 2019. Data for multiple years would facilitate analysis of changes in efficiency and productivity over time. Notwithstanding these limitations, these findings provide exploratory evidence about inefficiency in the manufacturing SME firms in Zambia. Future work should investigate factors that hinder manufacturing firms from utilising their plants fully. Some of these factors may include inadequate working capital, stiff competition, shortage of raw materials, constraints in the supply chain for raw materials, inappropriate capitalisation decision and poor management decision-making, among others.

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