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Determinants of Technical Efficiency in Kenyan Manufacturing Sector

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***Abstract*:** This paper uses World Bank's 2007 Regional Program for Enterprise Development survey data for Kenya to investigate the efficiency levels of Kenya's manufacturing sector and establish the sources of its variations across firms. Using a two-stage nonparametric approach, we establish the average technical efficiency of Kenya's manufacturing sector to be 68.3 percent with the least being 53 percent. Also, we find that 63 percent of the firms operated under increasing returns to scale, 35 percent of firms operate under decreasing returns and 2 percent under constant returns. Second stage results from Tobit estimation show that age of the enterprise and size enter the efficiency function negatively and their coefficients are significant. Technical efficiency is established to be concave with respect to these variables as well. The results also show that firms located in Nairobi are more efficient than their counterparts in Mombasa are. The implications of these findings for the design of policies that influence firm performance and location decisions are briefly discussed.

1. Introduction

According to Coelli *et al.* (2005) efficiency is a measure of a firm's performance. In particular, it is the firm's ability to successfully allocate inputs in a way that optimize on output production. From a microeconomic view, it can be contextualized into two different measures: allocative efficiency and technical efficiency. Of focus in the present paper is technical efficiency, which is the firm's ability to produce maximum output from a given set of factor inputs.

Lundvall and Battese (2000) note that for over two decades, empirical efforts have been devoted to the development of efficiency measurement models, which have resulted in two approaches to efficiency measurement[1] being developed. Empirical analyses of efficiency have utilized either data envelopment analysis (DEA) or stochastic frontier analysis (SFA), which is parametric in nature.

Within the context of sub-Saharan Africa there has been considerable attention on examination of the efficiency of firms within the region (see Lundvall and Battese, 2000; Adeoti, 2013; Chirwa, 2001; Graner and Isaksson, 2007). Most of the studies carried out within the region have adopted different methodologies. For instance, Chirwa (2001) and Lundvall and Battese (2000), while examining technical efficiency of Malawi's and Kenya's manufacturing sector applied the SFA framework. Limited empirical evidence exists on the determinants of technical efficiency of the Kenyan manufacturing sector as indicated from the reviewed literature. The existing literature within the Kenyan context has examined technical efficiency for the manufacturing sector in the 1990s, and there have been subsequent policy changes over time, and the dynamics of the industry has tremendously changed thus the need to look into the factors that influence technical efficiency in the manufacturing sector of Kenya.

This paper looks at the levels of efficiency of Kenya's manufacturing sector and the sources of their variation using a two-stage nonparametric approach. Using a unique firm-level dataset for 2007, we estimate the technical efficiency level and its determinants while controlling for heterogeneity. Results show Kenyan manufacturing firms are on average 68.3 percent efficient with the most efficient firm being from the electronics sub-sector with 71.92 percent. Also, we establish that there exists a concave relationship between a firm's technical efficiency on age and size. These findings confirm the hypothesis that as firms grow, they become more efficient in production due to the growing stock of experience (Jovanovic, 1982). We also find evidence that a firm's location plays a significant role in explaining the differences in efficiency which is in line with the new geography theory, which postulates about the benefits from the agglomeration of industries in certain areas over others.

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1.1 Overview of Kenyan Manufacturing Industry

The role played by the manufacturing sector in an economy is important, and according to Tybout (2000), the sector plays vital roles in enabling countries industrialize. This sector is an engine that drives economic growth for economies through the creation of employment opportunities, facilitating trade and thus enhancing a county's export sophistication by shifting the allocation of resources from low-value commodity dependence to high-value manufactures (Lavopa and Szirmai, 2012).

The manufacturing sector in Kenya comprises firms involved in consumer goods processing, crude petroleum refining, motor vehicle assembly and industries producing farm implements. The outputs of these products are consumed locally, and part of it is exported to other sub-Saharan African countries and developed countries. However, the volume of goods to the developed market is comparatively low compared to that going to sub-Saharan African countries. This is attributed to the low-quality nature of goods from these countries, thus locking them only to the domestic market.

According to annual statistics from the Kenya National Bureau of Statistics (2015), the sector constituted 70 percent of the industrial sector's contribution to GDP in 2015. The survey further shows that the GDP contribution of the sector has stagnated at about 10 percent over the last decade, with the sector's growth in 2014 being 3.4 percent compared to 5.6 percent in 2013. Also, Kenya's Vision 2030 identifies the sector as one of the sectors that will be responsible for attaining a sustained annual growth rate of 10 percent. It is envisioned that the sector will contribute 20 percent of the country's GDP. However, this can only be realized if underlying constraints[2] faced by the sector are addressed through the adoption of appropriate policies that would boost productivity.

Three major policy regimes are akin to the Kenyan manufacturing sector: import substitution, market liberalization and export promotion. Before independence, Kenya pursued an import substitution strategy but immediately after independence, the government enacted laws[3] aimed at retaining and attracting foreign investment. In 1967 the Kenya Industrial Estates was established with the sole purpose of motivating small entrepreneurs to participate in manufacturing. The period 1960–70 can be termed as a period during which the country adopted an import substitution industrialization strategy. This strategy gained immense support from the government; the government in particular provided direct support and protection of the industry. This was meant to ensure that domestic infant industries grow in the absence of intense competition from multinational corporations. The benefits of increased industrial growth were realized over this period (Were and Kayizzi-Mugerwa, 2009).

A turbulent macroeconomic environment characterized the 1970s for the Kenyan manufacturing sector. During this period, the performance of the economy was deteriorating. Despite that, the government continued to pursue import substitution while financing new industrial projects facilitated by the Industrial Survey and Promotion Centre established in 1970. The economy was further hit hard by the collapse of the East African community in 1977, the coffee boom and the oil shocks in this period as well (Foroutan and Pritchett, 1993).

The 1980s and 1990s are periods during which structural adjustment programs were introduced with the aim of strengthening competitiveness and ensuring that the industrial sector was operating at optimal capacity levels thus addressing the distortions[4] that had come along with the country pursuing import substitution strategy in the early 1960s and 1970s. Despite the adoption of structural adjustment programs, the economy continued to be constrained by insufficient exchange rate adjustments and inefficient fiscal adjustments (Chege *et al*., 2014).

Turning to the new millennium policies, a couple of significant events have occurred which in one way or the other have influenced the development of the manufacturing sector. One significant development is the enactment of African Growth and Opportunity Act (AGOA), which has had an important implication for the establishment of the textile industry not only to Kenyan manufacturing industries but also to African industries as well. The second significant development was in 2003 when the country developed the Poverty Reduction Strategy Paper, the Economic Recovery for Wealth Creation and Kenya Vision 2030, all with a focus on ensuring that the manufacturing sector remained vibrant. Lastly, the National Industrial Policy (NIP), which proposed the creation of institutions meant to coordinate and facilitate industrial development, was enacted in 2007.

1.2 Research Problem

Kenya's manufacturing industry has over the last decade experienced stagnation despite its overall growth potential. If the current trend continues to 2030, the growth forecasts in Kenya's Vision 2030 will not be attained. This, in turn, implies that the country may fail to attain the projected annual growth of 10 percent in GDP. The failure of this sector to grow will consequently imply that generation of employment opportunities would suffer. Thus, efforts of poverty reduction through job creation will also not bear fruit. It is critical at this point to assess the efficiency of the manufacturing sector with a view of coming up with policies that would steer the industry's performance upward. Improving efficiency of firms in this industry will enhance competitiveness and therefore increase their probability of survival in an industry characterized by intense competition.

1.3 Objectives of the Study

The paper seeks to establish the level of technical efficiency and the source of its variations in Kenya's manufacturing industry. The specific objectives are:

1. To establish the average technical efficiency of Kenya is manufacturing sector.
2. To analyze the factors that influence the technical efficiency of Kenya's manufacturing sector.

1.4 Justification of the Study

The aim of this paper is twofold; first, it seeks to assess to what extent firms are technically efficient and to establish covariates associated with the observed level of efficiency. The need for efficiency analysis has become more pressing in a world where firms face scarcity of resources. Also with the desire to maintain a stable market, especially in an environment characterized by intense competition from within and without the country arising from import liberalization, firms must be efficient in their operations hence increasing the chances of survival. An investigation of technical efficiency is of significance to both academic discourse and policy makers, and hence this paper contributes to the ongoing debates on efficiency and ways in which firms can improve their effectiveness. Similarly, the results of the analysis are of value to policy makers in enhancing their understanding of factors influencing efficiency, thus aiding them to formulate policies to boost firm productivity.

The organization of this paper is as follows: an empirical literature review is provided in Section 2. Section 3 presents the conceptual framework and Section 4 presents the results of the study. The conclusions and policy recommendations are presented in Sections 5 and 6, respectively.

2. Empirical Literature Review

Efficiency analysis has received considerable attention from different disciplines like engineering and economics as it is central to the existence of a firm. This attention has mainly been directed to the analysis of decision-making units such as hospitals, educational facilities, manufacturing industries and agricultural farms. Research of this kind has unearthed a myriad of factors perceived to affect the level of a firm's efficiency.

Empirical analysis has established that firm size influences firm's efficiency with bigger firms having higher efficiency arising from scale economies in production compared to young firms (Chen and Tang, 1987). Firm ownership was found to matter with locally owned firms being efficient compared to foreign-owned firms. However, local ownership could also be detrimental especially if the owners lack necessary managerial expertise or to resist the adoption of modern production techniques.

Lundvall and Battese (2000) in their study estimated a translog stochastic frontier production function for 235 manufacturing firms in Kenya using Regional Program for Enterprise Development (RPED) Investment Climate Survey for the period 1992/93. They asserted that technical efficiency was systematically related to firm size and age. In particular, they found that firm size had a significant positive effect for firms in the wood and textile sectors which became more profound as they grew older but was less systemic and insignificant in all sectors except textiles.

Chirwa (2001) adopted a deterministic production function to examine technical efficiency of Malawi's manufacturing sector. It established that the average technical efficiency ranged between 38 percent and 87 percent in the printing and publishing sector and the fabricated metal products sector respectively. The tea sector had the lowest technical efficiency score of 16 percent while the plastic sector had 55 percent. The variance in the efficiency scores was attributed to variation in firm and industry characteristics.

Ajibefun and Daramola (2003) in their study of the determinants of technical and allocative efficiency of 180 Nigerian micro-enterprises using a stochastic frontier approach established that education positively correlated with efficiency while the age of the enterprise owner correlates negatively with efficiency. They thus concluded that these variables are the most important and essential to the government in helping improve the sector's level of efficiency.

Graner and Isaksson (2007) investigate the link between firm efficiency and exports status for Kenyan manufacturing sector for the period 1992 to 1994 where they used a stochastic frontier analysis framework. The study found that the mean average technical efficiency of the Kenyan manufacturing sector was 55 percent and that exporting firms were more efficient than non-exporters. In particular, they found that exporting firms were 10 percent higher in mean technical efficiency for textiles to 67 percent greater in wood. The current study is different from their study both in the technique adopted in the analysis as well as the time period of examination. Whereas Graner and Isaksson (2007) looks at the period 1992–94, there has been several policy changes in the economy that has influenced the performance of the manufacturing sector.

Asid (2010) sought to establish the technical efficiency of manufacturing firms in Malaysia and adopted a stochastic frontier model. The results of the analysis established that technical efficiency of the firms was increasing at 0.01 percentage points annually. This increase in efficiency was attributed to the input-driven mode of production adopted by the firms. It also found that technical efficiency was rising over time but at a decreasing rate.

Ngeh (2014) employed a stochastic frontier analysis technique to estimate technical efficiency of Cameroon's manufacturing industries where they establish that the average technical efficiency ranged between 10.3 percent and 24.1 percent. They also report that firms aged above 20 years were the most efficient with a mean technical efficiency of 35.97 percent. On the other hand, Olatunji (2002) also explored the efficiency of manufacturing firms in Nigeria and found that firms, which had invested heavily in technology, were more technically efficient. However, it noted that inefficiency of firms was directly attributable to firm's characteristics.[5] In particular, the study established that efficiency increased as the firm size increased and was on a decline for firms that were locally owned as opposed to those foreign owned. It also found that skill intensity of workers also enhanced efficiency.

Mukwate and Muchai (2012) analyzed the efficiency differences and distribution within the Kenyan manufacturing sector. They applied a stochastic frontier analysis to an unbalanced panel data for the period 1992/93–1994/95 and 2000/01–2002/03. Their results indicated that nearly 48 per cent (53 per cent), 42 per cent (58 per cent), and 40 per cent (32 per cent) technical potentialities for the food, metal and textile subsectors respectively were not achieved in the 1992/93–1994/95 (2000/01–2002/03) period. However, their study did not focus on the determinants of the observed level of technical efficiency which is the focus of this study.

This paper is different from the previous works in three ways. First, it adopts a non-parametric DEA technique. Previous studies have mostly employed the SFA approach. The study's use of DFA over SFA is motivated by the advantages[6] it possesses. Despite its merits, it also has shortcomings.[7] Secondly, where estimations have been done on the Kenyan manufacturing sector analyses have utilized data for the period 1992 to 1994 (Graner and Isaksson, 2007; Lundvall and Battese, 2000). This period, however, does not reflect the present scenario of the Kenyan manufacturing industry since after this period the economy has undergone major reforms.[8] The present study, therefore, incorporates the new environment in which manufacturing firms are operating in by utilizing World Bank's 2007 wave of the Regional Program for Enterprise Development data which has so far not been used to analyze the efficiency of firms in Kenya using DEA. Lastly, previous studies have failed to include interaction terms (i.e. firm size squared and firm age squared) in their estimation yet there is no *a priori* reason to believe that efficiency scores have a linear relationship with its determinants. We also include various interaction terms in the estimation.

3. Conceptual Framework and Data

3.1 Data Envelopment Analysis (DEA)

Suppose there are K inputs and M outputs for N decision making units (DMUs), and let x_i and y_i represent K and M, respectively. DEA seeks to construct a non-parametric frontier that shows how far firms are away from the frontier. DEA can be expressed as a ratio of the form:

$$\frac{\mathbf{U}Y_i}{\mathbf{V}X_i}$$

where **U** and **V** are a vector of output and input weights respectively.

To obtain the optimal weights of **U** and **V** then the ratio should be maximized subject to a set of constraints such that the efficiency of the *i*th DMU is less than or equal to 1, in which case the DMU is said to be technically efficient.

$$\max_{u,v} \frac{\mathbf{U}' y_i}{\mathrm{V}' x_i}$$

Subject to

$$\frac{\mathbf{U}' y_j}{\mathbf{V}' x_j} \leq 1; \quad \text{for } j = 1 \ldots\ldots N \quad u, v \geq 0$$

Estimating the above implies that an infinite solution set exists for **U** and **V**. To address this problem an additional constraint of the form $v' x_i = 1$ is imposed and the problem reformulated as:

$$\max_{u,v} (u' y_i)$$

Subject to:

$$v' x_i = 1$$

$$\mu' x_j - \nu' x_j \leq 0, \; j = 1 \ldots\ldots N$$

$$\mu, \nu \geq 0.$$

The above problem is run *n* times in identifying the relative efficiency scores of all the DMUs. Each DMU selects input and output weights that maximize its efficiency score. A DMU is efficient if the score is one and if less than one, it is inefficient.

3.2 Determinants of Technical Efficiency

The technical efficiency scores obtained in stage one was regressed on the environmental variables deemed to affect it. Since the scores are on the interval $0 \leq \theta \leq 1$ this renders the dependent variable to be a limited dependent variable, which is censored from above and from below thus a necessary and sufficient condition to apply Tobit estimations as opposed to OLS estimations whose parameter estimates are biased (Maddala, 1983; Kmenta, 1990; Wooldridge, 2002). The Tobit model is estimated by the maximum likelihood estimator approach.

The Tobit model can be specified as:

$$y_i^* = \beta_0 + \sum_{i=1}^{K} \beta_i Z_i + \mu_i$$

where *i* is the *i*th DMU, y_i^* is the Latent efficiency variable, *y* is the efficiency score defined as:

$$y_i = \left\{ \begin{array}{ll} y^* & 0 \leq y^* \leq 1. \\ 0 & y^* < 0 \\ 1 & 1 < y^* \end{array} \right\}$$

β_i are the parameters to be estimated and μ_i is the error term, assumed to be independently and identically distributed. Z_i is a vector of environmental variables that affects U_i^* and explains the variations in firm's technical efficiency.

3.3 Data and Variables Definition

Technical Efficiency Measurement Variables

The paper makes use of cross-sectional data from the World Bank's Regional Program for Enterprise Development Investment Climate Survey for Kenya conducted in the year 2007. This survey was conducted for 396 firms constituting the manufacturing sector and was incorporated in our analysis of the technical efficiency. The firms were from nine sub-sectors, which are textiles firms, garments firms, leather firms, agroindustry firms, food firms, metals and machinery firms, electronics firms, chemicals and pharmaceutics firms and the construction firms. The variables are as discussed in Table 1.

Second Stage Estimation Variables

In estimating what influences a firm's technical efficiency, the explanatory variables adopted are measured as follows. We measured the age of the firm as the number of years the firm has been in operation; firm size is measured by the total value of plant, vehicles, equipment, land and buildings. The firm location is a dummy variable (i.e. whether the firm is located in Nairobi, Mombasa, Kisumu, and Nakuru). Ownership is measured as a dummy variable with a foreign-owned firm taking a value one otherwise zero. Technological innovation is also measured as a dummy variable and took the value one if the firm adopted any technology in 2006 otherwise zero. Managerial expertise is measured as the average number of years the managers have been in the firm, and finally, industry dummies were incorporated.

4. Empirical Results and Discussions

The summary statistics used for DEA and Tobit estimations are presented in Table 2. Logarithmic transformation of the variables was performed to normalize the variables thus eliminating the likely presence of outliers in the sample. Also, we use input-oriented, DEA[9] as opposed to the output-oriented DEA. The decision on which orientation to use depends on the factors (inputs or outputs) over which the firm has more control (Coelli *et al*., 2005), and since firms are more in control of the factors of production, we, therefore, use the input-oriented variable returns to scale efficiency measure.

The input-oriented variable returns to scale efficiency scores are presented in Table 3. The results show that the textile subsector had nine efficient firms, the leather subsector had four firms with the agroindustry, food and construction subsectors having one firm each. Overall, 16 firms were operating on the efficiency frontier. We also find that eight firms were operating under productive scale size representing 2.02 percent of the total firms under examination while 249 firms (62.88 percent) carried on under increasing returns to scale and 139 (35.0 percent) carried on under decreasing returns to scale. The average technical efficiency of the Kenyan manufacturing sector was established to be 68.3 percent, and this is different from results reported by Graner and Isaksson (2007) who found that the average technical efficiency for the period 1992–94 was 55 percent, an indication that there has been an improvement in the sector's efficiency.

Based on the observed level of efficiency if firms were to produce on the efficiency frontier, it would need to cut inputs by 31.7 percent and still produce the same output. However, the potential of input reduction would vary across the sector with the scope of producing 1.46 times (i.e. 1/0.6826) much more output from the same inputs.

Table 1: Input and output variables in data envelopment analysis

Variables	Measurement of variables
Output (*Y*)	Total value of sales both in the domestic and foreign market (exports) by the firm in 2006
Capital input (*K*)	Proxied by the total replacement value of plant, machinery, and equipment by the firm in 2006
Labor input (*L*)	The total number of production workers employed by the firm in 2006

Source: Author's computation.

Table 2: Summary statistics for firms in manufacturing sector in Kenya

Variable	Mean	Std. dev	Max	Min	Obs
Log of Output	18.00	1.97	24.02	13.02	396
Log of Capital	17.60	1.96	23.94	11.00	396
No. of Production Workers	103.01	259.60	2620	2.00	396
Log Firm Size	16.70	2.11	23.23	9.90	396
Firm Age	22.59	15.87	87.00	10.00	396
Managerial Expertise (years)	15.17	10.00	60.00	0.00	396
D_Nairobi	0.6919	0.4623	1.00	0.00	396
D_Mombasa	0.1288	0.3354	1.00	0.00	396
D_Nakuru	0.0859	0.2805	1.00	0.00	396
D_Kisumu	0.0934	0.2914	1.00	0.00	396
D_Ownership	0.8914	0.3115	1.00	0.00	396
D_Agroindustry	0.0227	0.1492	1.00	0.00	396
D_Chemicals & Pharmaceutics	0.0756	0.2649	1.00	0.00	396
D_Construction	0.1692	0.3754	1.00	0.00	396
D_Electronics	0.0783	0.2690	1.00	0.00	396
D_Food	0.0657	0.2480	1.00	0.00	396
D_Garments	0.0732	0.2608	1.00	0.00	396
D_Leather	0.2071	0.4057	1.00	0.00	396
D_Metals & Machinery	0.0303	0.1716	1.00	0.00	396
D_Textiles	0.2778	0.44847	1.00	0.00	396

Source: Author's computation based on RPED Survey Data.

4.1 Average Technical Efficiency by Firm Age and Location

Further, Table 4 shows the mean efficiency of firms according to their age and location. In particular, the results indicate that firms located in Mombasa and are aged more than 50 years are the most efficient (i.e. 68.08 percent) relative to other firms in the region. In Nairobi, the most efficient firms were those aged not more than ten years and had the efficiency level of 73.89 percent.

Table 3: Descriptive statistics of technical efficiency scores

Industry	TE (%)	SE (%)	No. of efficient firms	No. of inefficient firms
Textiles	69.89	94.28	9	101
Leather	71.33	96.74	4	78
Garments	67.79	97.33	0	29
Agroindustry	65.89	97.96	1	8
Food	63.72	97.42	1	25
Metals and Machinery	68.38	95.62	0	12
Electronics	71.92	95.21	0	31
Chemicals and Pharmaceutics	69.59	91.38	0	30
Construction	65.8	96.29	1	67
Mean	68.3	95.80		
Number of observations			16	380
Maximum TE for the sector		1.00		
Minimum TE for the sector		.531		
Firms experience constant returns to scale (CRS)			8 (2.02 percent)	
Firms experience increasing returns to scale (IRS)			249 (62.88 percent)	
Firms experience decreasing returns to scale (DRS)			139 (35.0 percent)	

Note: TE = technical efficiency scores, SE = scale efficiency scores.
Source: Author's computation.

Table 4: Mean efficiency scores for manufacturing sector by age and location

	Location of the firm			
Firm's age	Mombasa	Nairobi	Nakuru	Kisumu
Less than10 years	59.39	73.89	69.91	73.36
11–20 years	67.20	66.59	67.86	73.13
21–30 years	66.34	66.50	66.68	66.57
31–40 years	61.38	67.43	89.78	67.66
41–50 years	64.98	72.64	62.96	71.59
Above 50 years	68.08	70.22	96.40	61.63

Source: Author's computation.

This is an indication that younger firms easily adopt new technologies and innovations in their production processes. On the other hand, firms aged over 50 years in Nakuru were the most efficient at approximately 96.40 percent level of efficiency. Firms with less than 10 years and particularly from Kisumu were found to be most efficient (i.e. 73.36 percent level of efficiency). The results also show that younger firms located in Nairobi and Kisumu are more efficient compared to older firms. The finding that younger firms are more efficient compared with older firms resonates with the hypothesis that older firms may not be willing to try innovative techniques and technology due to financial constraints. As a result, are likely to be less efficient compared to younger firms who use the latest innovations and technology. The proposition that younger firms are more efficient than older firms does not seem to hold for firms in Nakuru and Mombasa as compared to those from Kisumu and Nairobi.

4.2 Average Technical Efficiency by Firm Ownership and Location

Table 5 shows the technical efficiency of the manufacturing sector by ownership status and its location. In particular, the results indicate that manufacturing firms that are foreign owned are more efficient (i.e. 69.1 percent) as compared to firms owned domestically (i.e. 67.7 percent). This observed disparity in technical efficiency is consistent with the long-held view that foreign ownership is a vehicle for the international transfer of management skills, technical know-how, and market information that cannot be licensed out or transferred to clients via technical assistance arrangements.

The results also indicate that firms located in Nakuru are more efficient in production compared to those located in Nairobi, Kisumu, and Mombasa (i.e. they are 71.1 percent efficient in their production). Firms located in Kisumu are 70.2 percent efficient, those in Nairobi are 69.3 percent efficient, and lastly, those in Mombasa are 64.5 percent efficient. This disparity could arise from the production costs incurred by the different firms in these regions. Firms in Nakuru and Mombasa, in particular, enjoy a locational advantage. The cost of labor for firms in Nakuru is relatively cheap as compared to labor costs in Nairobi or Kisumu.

Table 5: Mean efficiency for manufacturing sector by ownership and location

Variable	Nature of firm	Efficiency scores
Ownership	Domestic firms	0.677
	Foreign firms	0.691
Firm location	Kisumu	0.702
	Mombasa	0.645
	Nairobi	0.693
	Nakuru	0.711

Source: Author's computation.

4.3 Determinants of Technical Efficiency

Robustness Checks

A range of robustness checks is undertaken in order to examine the sensitivity of the estimated model. In particular, we test for model specification, heteroscedasticity and also different model specifications so as to determine the adequacy of the model. The results as indicated in Table 6 show that the model is adequately specified as the linktest[10] showed that the predicted and predicted hat squared have no explanatory power and thus the null hypothesis of a significant explanatory power of these variables is rejected at 5 percent level of significance.

Secondly, robustness checks with different model specifications are considered to examine the results more closely. The reported results are also robust to the violations of the assumption of homoscedasticity. To ensure that the results are robust to this violation the Huber-Sandwich estimator was used. Also, four models are estimated and thus the estimation of the model was additively done, and the significance of the variables included was established. As indicated in Table 6, the final additive model whose results are reported is model 4 where additional sector specific industry dummies are included, geographical dummies and interactions are also presented.

Table 6: Two-limit Tobit equations for technical efficiency for a sample of 396 manufacturing firms in Kenya

Variables	Model 1	Model 2	Model 3	Model 4
Firm Age	–0.003 (–2.10)**	–0.003 (–2.12)**	–0.003 (–2.04)**	–0.002 (–1.55)
Age-Squared	0.00004 (2.23)**	0.00005 (2.25)**	0.00004 (2.18)**	0.00004 (2.17)**
Log Firm Size	–0.157 (–3.98)***	–0.161 (–4.11)***	–0.159 (–4.24)***	–0.158 (–4.29)***
Firm Size-Squared	0.004 (3.58)***	0.005 (3.74)***	0.004 (3.86)***	0.005 (3.92)***
Firm Ownership	0.010 (0.57)	0.012 (0.62)	0.011 (0.52)	0.010 (0.49)
D_Nairobi	0.028 (1.77)**	0.031 (1.85)**	0.034 (1.93)**	0.045 (1.35)
D_Nakuru	0.061 (2.60) ***	0.057 (2.27)**	0.068 (2.68)***	0.007 (0.17)
D_Kisumu	0.039 (1.74) *	0.044 (1.85)**	0.047 (1.96)**	0.094 (2.19)**
Technological Innovation		–0.017 (–1.27)	–0.015 (–1.14)	–0.017 (–1.25)
Managerial Expertise		0.0002 (0.29)	0.0005 (0.57)	0.0004 (0.51)
D_Electronics			0.032 (1.13)	0.036 (1.27)
D_Construction			0.009 (0.39)	0.013 (0.57)
D_Textiles			0.042 (1.86)*	0.046 (1.97)**
D_Leather			0.036 (1.47)	0.038 (1.54)
D_ Chemicals & Pharmaceutics			0.049 (2.01)**	0.051 (2.06)**
D_Metals & Machinery			0.020 (0.49)	0.033 (0.81)
D_Garments			0.010 (0.37)	0.007 (0.27)
D_Agroindustry			0.025 (0.47)	0.029 (0.55)
Age*Nairobi				–0.0004 (–0.41)
Age*Nakuru				0.003 (2.05)**
Age*Kisumu				–0.002 (–1.40)
N	393	393	393	393
sigma	0.1087	0.1087	0.1076	0.1078
McFadden's R^2	0.1667	0.167	0.184	0.182
McFadden's Adj. R^2	0.125	0.121	0.105	0.124
Hat	4.012 (2.32)	4.190 (2.43)	2.261 (1.41)	2.42(–0.93)
Hat squared	–2.02 (–1.75)	–2.15 (1.85)	–0.860 (–0.79)	–0.950 (1.59)
F-test	$F(10, 385)$	$F(10, 383)$	$F(18, 375)$	$F(21, 372)$
Prob > *F*	0.0000***	0.0000***	0.0000***	0.0000***

Notes: *t*-values are reported in parentheses.
*, ** and *** indicates significance at 10%, 5% and at 1% respectively.
Source: Author's computation.

Tobit Estimates of the Determinants of Technical Efficiency

Table 6 presents the Tobit estimations of variables determining Kenyan manufacturing firm's technical efficiency. The estimations proceed in four levels. Estimates presented in column 4 include interactions effects (i.e. between firm location and firm age). The coefficient on firm age after incorporating all variables without interaction was estimated to be −0.003, and that of firm age squared to be 0.00004, both being significant at 5 percent, suggesting the existence of concavities between firm age and firm's technical efficiency. As such, the turning point of the U-shaped relationship can be computed by taking the partial derivative of Tobit model with respect to firm age as follows:

$$\frac{\partial(\mathrm{TE})}{\partial(\mathrm{Firm\,Age})} = 2[0.00004 * \mathrm{Firm\,Age}] - 0.003$$

Solving the above expression shows that the optimal firm age is 37.5 years implying that technical efficiency for firms declines before a firm is 37.5 years and reverts to an upward trend beyond 37.5 years. Upon interacting firm age and firm location, firm age becomes insignificant in influencing technical efficiency but the concavity condition is maintained. However, for firms in Nakuru, an additional year of operation increases their efficiency levels by 0.003. The sign of the coefficient of firm age on efficient is consistent with the findings documented in Graner and Isaksson (2007) where they found that firm age has a significant negative sign. The unexpected negative effect of firm age may be explained by the possibility that relatively young firms utilize more recent technology, while older firms are stuck with relatively old physical capital. In this case, older firms may be employing capital of an older vintage which is less productive than the industry average, and this leads to a technical decrease with firm age.

Secondly, the coefficient on log firm size is −0.159 after including all the relevant variables and before interaction and becomes −0.158 after the interaction. The coefficient on log firm size squared is 0.004 and 0.005 before and after interactions respectively.

Also, this indicates the existence of a concave relationship between log firm size and technical efficiency. The point of inflection is computed by taking the partial derivative with respect to log firm size then setting to zero as follows:

$$\frac{\partial(\mathrm{TE})}{\partial(\log\mathrm{Firm\,Age})} = 2[0.004 * \log\mathrm{Firm\,Age}] - 0.159 = 0$$

The optimal log firm size is therefore 19.875; this implies that a firm's technical efficiency will be low before it attains this threshold and beyond it the technical efficiency will be on an upward trend. The finding that firm size exerts a negative effect on efficiency seems to contradict the findings of Lundvall and Battese (2000) who found evidence of a significant positive effect of firm size on technical efficiency for the wood and textile sectors; however, from the literature reviewed by Lundvall and Battese (2000) they concluded that the relationship between technical efficiency and size is mixed. It is possible, therefore, that smaller firms due to their organizational structure and decision-making flexibility and simplicity are more efficient compared to larger firms.

Thirdly, the results indicated that a firm's location is an important factor that affects a firm's level of efficiency. Results show that firms located in Nairobi are more efficient with 3.4 efficiency scores above those in Mombasa while firms in Nakuru and Kisumu are also efficient with 6.8 and 4.7 efficiency scores higher relative to those in Mombasa. However, after interactions between firm age and firm location only firms in Kisumu are found to be more efficient than firms in Mombasa and in particular having an efficiency level higher by 9.4 scores. Lastly, the results indicate that the textiles sector is more efficient relative to the food industry and has 4.2 efficiency scores higher. Further, the chemical and pharmaceuticals sector has an efficiency level that is greater by 4.9 scores than that of the food sector before interaction effects are taken into account. After accounting for the interaction effects, it is established that the textile sector and the chemical and pharmaceuticals sector are efficient by 4.6 and 5.1 scores higher relative to the food sector respectively.

5. Conclusions

In this paper, we employed the DEA approach to estimate technical efficiency in Kenya's manufacturing. Analysis at the sectoral basis indicated that the sector on average is 68.3 percent technically efficient; pointing out that there is substantial scope for efficiency improvement at the industry level. We also find that 62.88 percent of firms operated under increasing returns to scale, 35.0 percent operated under decreasing returns to scale and 2.12 percent operated under constant returns to scale. Moreover, we find that the most efficient firms are in the chemicals and pharmaceutical sector. The second stage Tobit regression estimates shows that the effect of firm age and firm size has a significant negative effect on technical efficiency while firm ownership has an insignificant positive effect. The optimal age at which firms are considered most efficient is established to be 37.5 years. Further, the two factors have a concave relationship with technical efficiency. Finally, a firm's location positively affected a firm's efficiency level with firms in Nakuru, Nairobi, and Kisumu being more efficient to those in Mombasa. To improve firms' efficiency, and thus stimulate industrial competitiveness, the findings suggest that firms should examine their production structures while taking cognizance of the factors that may further improve technical efficiency.

Notes

1. The two approaches to efficiency measurement is the DEA approach, which is non-parametric in nature, and the SFA approach, which is parametric in nature and is built on an econometric foundation. As will further be discussed in Section 3.1, DEA does not impose any functional specification in the measurement of efficiency as compared to SFA, which does.
2. The constraints that hamper growth of the manufacturing industry include: (i) inadequate access to credit facilities, (ii) high cost of productions, (iii) international shocks. These factors therefore lead to perpetuation of inefficiency within the sector.
3. For instance, in 1964 the government enacted the Foreign Investment Protection Act. With the enactment of this Act, foreigners were given the leeway to repatriate profits and interest on loans.
4. These distortions include price controls and tariffs that had resulted in reduced competitiveness in the sector as industries were behaving more like monopolies.
5. The firm characteristics under consideration in Olatunji's (2002) study included firm size, ownership structure, skill intensity and firm age.
6. DEA according to Charnes *et al.* (1978): (i) does not require *a priori* functional specification; (ii) it allows for multiple inputs and outputs; (iii) it decomposes technical efficiency into two parts the scale and overall technical efficiency; and (iv) it also identifies firms operating under increasing or decreasing returns to scale.
7. The DEA approach assumes that the data is free from measurement error, which in reality is impractical (Avkiran, 1999).
8. During the period 1992–93, the Kenyan economy underwent major reforms with the manufacturing sector being heavily affected by them. For instance, during this period export-oriented reforms were adopted and the economy liberalized.
9. In examining technical efficiency, using the non-parametric DEA two approaches can be used: input or output oriented DEA models. Input-oriented DEA shows by how much input quantities can be reduced without varying the output quantities produced. Output-oriented DEA assesses by how much output quantities can be proportionally increased without changing the input quantities used. The two measures provide the same results under constant returns to scale but give slightly different values under variable returns to scale. Nevertheless, both output-oriented and input-oriented models will identify the same set of efficient/inefficient manufacturing firms.
10. The linktest is a STATA command that was used to check for model specification. The null hypothesis of the test is that the model is not correctly specified against the alternative hypothesis of a correctly specified model.

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