Efficiency of Manufacturing Establishments in Eritrea

Tuccu Selomon*

Abstract

This paper discusses productive efficiency of a sample of firms using World Bank data from a sample of 179 Eritrean manufacturing firms. The results of the estimation of the technical efficiency model shows Eritrean manufacturing firms in general are inefficient. The study further investigated firms' efficiency by nature of ownership, age of firm, experience of the entrepreneur and managers' education. Both labour and capital are more productive under sole proprietorships or partnerships than incorporated firms. Labour is more productive for older firms and capital is more productive for younger firms. Results also show labour is more productive for firms with less experienced managers, while capital is more productive for high experienced managers. Also, labour is productive for both firms that are managed with less educated managers and high educated managers. In almost all cases return to scale appears to be less than one, suggesting the existence of high inefficiency. In general there was no significant difference in the existence of embodied technology among firms. The study suggests that firms need to examine and invest in technology and skills that may contribute to improved efficiency.

Keywords: efficiency, manufacturing firms, Eritrea

1. Introduction

This study tries to compare the efficiency of manufacturing firms among selected establishments in Eritrea. There are several measures of efficiency. In this study efficiency of a producer implies a comparison between observed and optimal values of its output and input. Producers are efficient if they have produced as much as possible with the inputs they have actually employed, and if they have produced that output at minimum cost (Greene, 1997). The exercise may also involve comparing observed output to maximum potential output obtainable from the input, or comparing observed input to minimum potential input required to produce the output, or some combination of the two. In these two comparisons the optimum is defined in terms of production possibilities (Debreu, 1951; Farrell, 1957). In other words efficiency is measured by comparing observed and optimum cost, revenue, and profits.

The manufacturing industry in Eritrea is dominated by small and medium firms, which are labour-intensive and employing low level automations. The feature of

* College of Business and Economics, Halhale , Eritrea

this industry is normally linked to low efficiency. This paper attempts to examine the efficiency of the manufacturing industry by considering input elasticities, returns to scale, and to a lesser extent, embodied technology. The study further makes a comparative analysis of efficiency by reclassifying firms by size, age, nature of business ownership, and managerial education as well as experience.

2. Theoretical Review

As a concept, efficiency can be defined as the difference between observed and optimal values of inputs, outputs, and input-output mixes (Bos & Kolari, 2005). The starting point for efficiency studies is determining the inputs and outputs of firms. In the case of the input oriented approach, in order to attain a given level of output, input levels are optimized (or minimized) to attain a given level of output. Such approach can be utilized where the objective is to minimize input cost. In the output oriented approach, on the other hand, the output level are optimized (or maximized) with a given level of input. This approach stresses on the effective usage of inputs.

Although there are a number of different efficiency measures, the two most common approaches are technical efficiency and allocative efficiency (Sanjeev, 2006). As proposed by Farrel (1957), technical efficiency is the ability to produce a given level of output with a minimum quantity of inputs under a given technology. The efficiency term describes the maximum outputs attainable from utilizing available inputs. A production is efficient if it cannot improve any of its inputs or outputs without worsening some of its other inputs or outputs. Efficiency can be increased by minimizing inputs while holding output constant, or by maximizing output while holding inputs constant, or a combination of both may increase efficiency.

The production function is used in this paper to assess efficiency. The production function is the technical relation that connects factor inputs and outputs given existing technology available at any particular time. Output deviations from the production frontier are assumed to be a result of technical inefficiency. Technical efficiency is the ability to produce maximum amount of output with a given level of input (Worthington, 2000). In another words, technical efficiency is the ability to produce a given level of output with minimum level of input (Hauner, 2005). On the other hand, allocative efficiency is the utilization of inputs in optimum proportions with given input price levels (Worthington, 2000; Bos and Kolari, 2005).

Chen and Tang (1987) enumerate firm attributes that may affect efficiency and performance to include firm size, age of the firm, ownership structure and managerial experience. The issues of whether larger firms are efficient than smaller firms, or vice-versa; and whether older firms are efficient than younger firms, or vice-versa, have generated large amounts of theoretical and empirical

research in economics and management. Larger firms are usually considered to be more efficient than smaller firms because they are thought to have superior organisational and technical knowledge. Older firms are usually considered to be more efficient than younger ones because they can gain experience from past operations, and their survival *per se* may reflect their superior efficiency. Over time, firms discover what they are good at, and learn to be more efficient (Jovanovic, 1982). They specialize and find ways to standardize, coordinate, and speed up their production processes, as well as to reduce costs. Yet, the theoretical postulates and empirical evidence are equivocal, at best, on the impacts that size and age have on firm efficiency, and it is likely that the true nature of the relationship is very environment-specific, and highly dependent on a number of institutional factors that affect the performance of firms.

Several empirical studies using frontier function methodologies have been undertaken with the purpose of measuring firm efficiency, but with different results. These differences may have been due numerous reasons, including the time period analysed, the degree of sample homogeneity, output aggregation and the method employed (Neff et al., 1991). For example, Bravo-Ureta and Rieger (1990) examine New England and New York farm efficiency using four production frontier methods. The results of their analysis show that, while large differences exist between estimated average firm efficiency ratios, all four sets of efficiency ratios are correlated within two time periods.

Sharma et al. (2003) estimated technical efficiency and total factor productivity growth in 50 US states from 1977 to 2000 and found that, on average, technical efficiency is around 75%. Other studies on regional technical efficiencies that use different methods include Osiewalski et al. (2000) and Maudos et al. (2000). Osiewalski et al. (2000) examined productivity disparity between Poland and other Western economies using a Bayesian stochastic frontier. They claimed that at the beginning of Poland's reform its economy exhibited low technical efficiency. Maudos et al. (2000) employed data envelopment analysis to estimate efficiency in Spanish regions using panel data from 1964 to 1993, observed that efficiency varies across sectors and time.

3. Development and current status of Manufacturing in Eritrea

Eritrean firms have suffered from inefficiencies in domestic production and trading systems, stemming from long time war and centrally planned economy during the 70s and 80s. As early as the 1930s and 1940s, Eritrea had an industrial base established, primarily by the Italians who colonized the country from 1989 to 1941. The colonial powers first built road and rail network that connected the country between the Red Sea cost and the fertile hinterland. This was followed by a rapid development of small and large cities. As a result many trade, manufacturing and

service establishments were developed. By the 1950s and early 1960s a good number of import substitution industries were established; and these included food processing, textiles, leather and leather goods industries (UNIDO, 2003).

Between 1961 and 1991 the country was under the British and Ethiopian rule. The growth of industrial and service establishment declined during this period. During the thirty years of liberation struggle, i.e., from 1961 to 1991, the economy was in a steady decline, and the limited infrastructure was severely damaged (Kidane, 2011). Following its independence in 1991, and in response to the slow economic growth, the government instituted a major economic reform that aimed at moving away from centrally planned economy to a market economy. The government issued a comprehensive macro policy indicating the strategies for development, including strategies for achieving food security and industrial development. This has lead to the revival of the economy. Between 1992 and 1998 GDP at factor cost and at market price grew by 9% and 6, respectively. Income per capita increased from 818 Nacfa (117 USD) in 1992 to 1199 Nacfa (171 USD) in 1998 (Kidane, 2001, Aryettee, 2011).

Resumption of growth has enabled manufacturing firms to envisage restoring production plants. However, the aftermath of the recession is still evident. In addition to the constraints affecting all sectors, Eritrean firms are facing specific difficulties such as competition from imports, internal weaknesses in output, low technology acquisition, marketing and management expertise as well as electricity supply shortages. All these and other factors have reduced effective capacity utilization in firms, and increased production costs.

It is in this background that we analyze the efficiency of Eritrean manufacturing establishments. The study will be a cross-national analysis, and will be confined to non-agricultural firms.

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4. Data source

This study draws on information obtained from the World Bank enterprise surveys in Eritrea (World Bank, 2010). The sample covers small, medium and large-size manufacturing and service firms. A total of 179 firms, out of a of 608 firms, employing at least 5 permanent workers were included in survey. The survey was conducted on firms located in three industrial regions in Eritrea: Debub, Maekel, and Northern Red Sea. The sample frame was stratified by location, sector, and size. Similarly, eight broad sectors were defined: chemicals, paints and pharmaceuticals, food and beverage, metal, paper/printing and publishing, plastics, textile, leather, and garments, furniture, and construction. The sample covers small, medium and large-size manufacturing firms. The survey collected information on historical data on employment, production variables, firm

characteristics, various performance measures, background of the entrepreneur, institutional constraints to growth, and business environment aspects.

5. Methodology

Economic theory of production provides the analytical framework for most empirical research on productive efficiency. At the core of the theory is the production function, which postulates a well-defined relationship between a vector of maximum producible outputs and a vector of factors of production. Production function modelling is an important tool in analyzing returns to scale, technical change, and productivity changes. This paper uses Cobb-Douglas production function (Cobb and Douglas, 1928) to investigate the efficiency of the firms.

General model:

A simple unspecified is expressed as

$$Y_i = (K_i, L_i, \varepsilon_i) \quad \text{.....1}$$

Where Y is the output for firm i as measured in terms of sales value, K is corresponding capital input (the measure of capital input is the book value of capital stock of the firm), L labour input (total employment), and $\mathcal{E}$ is the error term.

Equation 1 is specified by a Cobb Douglas type production function of the following form:

$$Y = AK^{\alpha} L^{\beta} \varepsilon \quad \text{..... 2}$$

The functional form specified above assumes a non-constant return to scale with constant elasticity of substitution between capital and labour. α and β are the output elasticities (productivity indicators) of capital and labour respectively. The constant-A- may be assumed to measure an embodied technology.

Expressing equation 2 in log form we get

$$\log Y = \log A + \alpha \log L + \beta \log K + \log \varepsilon \quad \text{.....3}$$

Note:

$$\alpha = \frac{dY}{dL}\frac{L}{Y}$$

$$\beta = \frac{dY}{dk}\frac{k}{Y}$$

$\frac{dY}{dL}$ = marginal product of labour

$\frac{dY}{dk}$ = marginal product of capital

6. Empirical results

6.1 Descriptive statistics

The descriptive statistics considers the distribution of sales, which is our measure of output, along with the distribution of labour and capital -- the two main inputs whose productivity will measure efficiency.

The findings from Table 1 show that the 44.13% of the firms have the lowest level of sales, which is below 500,000 Ncfa followed by firms with sales between 2m to 4m Nacfa (16.76%). The firms have mean sales of 2.9m Nacfa, with a very high coefficient of variation.

Table 1: Sales

In thousand (Nacfa)	**Frequency**	**Percentage**	**Cumulative percentage**
Below 500	79	44.13	44.13
500 – 1000	16	8.94	53.07
1000 – 2000	26	14.53	67.60
2000 – 4000	30	16.76	84.36
4000 – 6000	9	5.03	89.39
Above 6000	19	10.61	100.00
Total	**179**	**100.00**	
Mean		2867.4	
Std Dev.		6831.6	
CV in %		238.2	

Table 2 shows that the 43.02% of the firms are small firms employing below 10 employees. This appears to be consistent with the results in Table1. This is followed by firms employing 10 to 20 employees. One can also note that the majority of the firms (78.21%) have below 20 employees. The mean number of employees per establishment is 19, with a very high coefficient of variation.

Table 2: Labour

Number of employees	Frequency	Percentage	Cumulative percentage
Below 10	77	43.02	43.02
10 – 20	63	35.20	78.21
20 – 30	13	7.26	85.47
30 – 60	13	7.26	92.74
Above 60	13	7.26	100.00
Total	**179**	**100.00**	
Mean		19.23	
Std dev.		26.6	
CV%		138.3	

Capital input is expressed in monetary value. 40.86% of the firms have a capital outlay of below 10,000 Nacfa. An important observation from Table 3 is that 77.42% of the firms have a capital below the average. This may be because some firms have relatively high capital that can make the average to skew towards those figures. The mean capital input is 99,900 thousand Ncfa, and with a high level of variation.

Table 3: Capital

In thousand NACFA	Frequency	Percentage	Cumulative percentage
low 10	38	40.86	40.86
10 – 25	11	11.83	52.69
25 – 50	10	10.75	63.44
50 – 75	13	13.98	77.42
Above 75	21	22.58	100.00
Total	**93**	**100.00**	
Mean		99.9	
Std dev.		257.9	
CV%		258.0	

6.3 Findings

We have already noted that efficiency is assessed by labour and capital elasticity, returns to scale, as well as embodied technology. Besides estimating the production function for all the firms, we will also replicate the estimation by subgroups, including the nature of ownership, firm age, experience of the manager, as well as the level of education of the same. We assume that the constant term of the estimated production is a measure of embodied technology. We will interpret the latter when comparing sub-group production functions.

6.3.1 Firms Efficiency – Overall

The results in Table 4 indicate that the model fits well (Prob>F=0.000). The three coefficients -- embodied technology, elasticity of labour, and capital -- have the expected positive signs, implying that an increase in an input ultimately increases the output level. All the three coefficients of the Cob Douglas production functions are significantly different from zero at 1% level. Summation of the elasticities of production (both labour and capital) indicates a return to scale of 0.86. The value of return to scale is less than 1, suggesting a decreasing return to scale is prevailing, which indicates a firm as being less efficient. When one compares the elasticities of the two inputs, labour (0.56) seems to be more efficient than capital (0.20), i.e., labour is more productive than capital. A hundred percent increase in labour input increase output by 56% given that capital is constant; the corresponding response for capital is a mere 20% (see Table 4). The level of embodied technology also appears to be significant.

Table 4: Firm overall efficiency

	Coefficient	**Standard error**	**t**
Labour (a)	0.56	0.20	2.82
Capital (b)	0.30	0.08	3.65
Constant term	9.26	0.94	9.83
R^2		0.3	
F		13.58	
Prob>F		0.000	
N		60	

6.3.2 Efficiency by nature of ownership

It has been shown above that overall firms are inefficient. Results of efficiency by the nature of ownership are investigated in order to compare the performance of sole proprietors or partnerships, and incorporated firms. The two production function appear to fit well (Prob>F<0.02). The results in Table 5 may be summarized as follows:

- In terms of return to scales we have a value of 0.86 for sole proprietorship and partnership; the corresponding value for registered or incorporated firms is 0.6, suggesting that the latter are less efficient than the former.
- Both labour and capital are more productive (efficient) under sole proprietorship and partnership when compared to registered or incorporated firms.
- Registered or incorporated firms seem to acquire more embodied technology when compared to sole proprietorship and partnership.

Table 5: Efficiency by legal status

	Sole proprietorships and partnerships			**Registered and Incorporated firms**		
	Coefficient	***Standard error***	***t***	***Coefficient***	***Standard error***	***T***
Labour (a)	0.56	0.25	2.25*	0.33	0.18	1.79
Capital (b)	0.30	0.09	3.16*	0.27	0.10	2.60*

Constant term	9.24	1.12	8.25*	10.86	1.11	9.75*
R^2		0.24			0.61	
F		8.91			7.37	
Prob>F		.001			0.02	
N		51			9	

Note: *Significant at t < 0.05

Even though both groups appear to be less efficient, sole proprietorship and partnership appear to be more efficient than individual ownership or partnership.

6.3.3 Efficiency by firm age

Efficiency has also been investigated to see how older firms are performing compared to the younger ones. Firms that were established in 2000 and before are considered old firms, where as those that are established in 2001 and after are considered old. Table 6 shows the production function of the two groups of firms.

Table 6: Efficiency by the age of the firms

	Firms established before 2000			**Firms established 2001 and after**		
	Coefficient	**Standard error**	**t**	**Coefficient**	**Standard error**	**t**
Labour (a)	0.29	0.24	1.21	1.22	0.47	3.29*
Capital (b)	0.33	0.09	3.74*	0.08	0.21	0.36
Constant term	9.9	1.11	8.89*	9.58	1.90	5.05*
R^2		0.29			0.40	
F		8.00			8.91	
Prob>F		0.01			0.01	
N		35			25	

Note: *Significant at t < 0.05

The following conclusions may be made:

- Younger firms have higher returns to scale (and thus more efficient) than older firms.
- For old establishments, capital is a very important contributor of efficiency; while labour's contribution is non-significant. The opposite is true for new establishments.
- There is not much difference on the extent of embodied technology.

6.3.4 Efficiency by experience of managers

Here we discuss the efficiency of firms in terms of managerial experience. Managers with an experience of less than 10 years are considered as of low experience, whereas those with more than 10 years are classified as high experienced managers.

Table 7 presents the estimated production function of less and more experienced managers. Both estimates have a good fit (Prob>F<0.05)

Table 7: Firms efficiency by managers' experience

	Less experienced managers**			**High experienced managers*****		
	Coefficient	***Standard error***	***t***	***Coefficient***	***Standard error***	***t***
Labour (a)	0.75	0.36	2.07*	0.44	0.24	1.81
Capital (b)	0.10	0.16	0.61	0.35	0.10	3.55*
Constant term	10.62	1.62	6.55*	9.25	1.29	7.18*
R^2		0.14			0.32	
F		3.12			8.28	
Prob>F		0.06			0.01	
N		28			32	

Note: * = Significant at t < 0.05; ** = Managers below 10 years of experience; *** = Managers with 11 and above years of experience

The following observations are extracted from Table 7:

- Returns to scale among less experienced managers is 0.86 which is slightly larger than those of more experienced managers (0.79)
- Labour's contribution to efficiency is high among less experienced managers while capital's contribution to efficiency is high among more experienced managers
- Compared to more experienced managers, firms with less experienced managers appear to possess higher embodied technology

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6.3.5 Efficiency by managers' education

In order to assess and compare efficiency by education of the managers, the level of education is categorised into two. These include managers with post-secondary level of education, and managers who studied up to secondary level of education.

Table 8 presents the production function of the two groups, the results show that both equation estimates as having a good fit. Compared to the previous cross classified result, classification by education shows a clear distinction between the two.

Table 8: Efficiency by education

	Up to secondary education			**Post-secondary education**		
	Coefficient	***Standard error***	***t***	***Coefficient***	***Standard error***	***T***
Labour (a)	0.72	0.25	2.89*	0.62	0.30	2.07*
Capital (b)	0.32	0.10	3.25*	0.55	0.16	3.51*
Constant term	8.98	1.12	8.01*	5.95	1.90	3.13*
R^2		0.37			0.40	
F		10.80			9.33	
Prob>F		0.001			0.001	
N		34			26	

Note: * = Significant at t < 0.05

The following results are observed from Table 8:

- Returns to scale among firms with highly educated managers is 1.17, which is higher than firms with less educated managers (1.04); suggesting that the former as more efficient than the latter.
- Among firms with less educated managers, labour contributes more to efficiency than capital. The opposite is true with capital inputs.
- There appears to exist a relatively high embodied technology among firms with less educated managers when compared to firms with more educated managers.

Table 9 gives a summary of the four classifications considered above.

Table 9: Summary of firms' contribution to efficiency*

Classification		Return to scale	Labour	Capital	Embodied Technology	Total no of +
Legal Status	SPP*	+	+	+	-	3
	Registered	-	-	-	+	1
Age of firms	Young	+	+	-	-	2
	Old	-	-	+	+	2
Manager's experience	Less experience	+	+	-	+	3
	More experience	-	-	+	-	1
Manager's education	Low education	-	+	-	+	2
	High education	+	-	+	-	2

Notes: *+ = high contribution,-= low contribution

Based on the tabular summary in Table 9, one can clearly conclude the legal status of a firm, as well as managers experience, contribute significantly to efficiency. It appears that firms that are classified as sole proprietorship or partnership are relatively more efficient than registered ones. One may also conclude that firms with less experienced managers appear to perform well. This appears to be counter-intuitive. However, it may be argued that managers of longstanding experience may not be receptive to new ideas or technology, while their younger counterparts may be willing to try new ideas.

7. Conclusion and implications

The paper examined the manufacturing efficiency of firms in Eritrea in order to provide insight on how to improve their efficiency. A Cobb-Douglas production function was used to compare the efficiency of labour and capital inputs. Return to scale and embodied technology were also considered. The overall results indicate that firms are inefficient since the elasticities of production for labour and capital (together) show a decreasing return to scale.

Despite being able to increase production over the years, firms in Eritrea produce at a low level of efficiency. This has resulted into an inefficient utilization of resources and thus the potential to increase output from the existing level of inputs.
The study further investigated the efficiency of firms by the nature of ownership, age of firm, experience of entrepreneur, and managers' education. In relation to the nature of business, incorporated firms were found to be capital intensive, whereas sole proprietors were labour intensive. Both labour and capital are more productive under sole proprietorship or partnership compared to incorporated firms. In comparison to firms that were established before 2000, labour is more productive for firms that established after 2001. Capital is more productive for firms established before 2000. Capital is also more productive for firms managed by highly experienced managers, while labour is more productive for firms that have low experienced managers. Finally, labour is productive for both less educated managers and high educated managers.

In order to improve the firms' efficiency, and thus stimulate industrial competitiveness, the findings of the study suggest that firms should examine and invest in technology and skills that may contribute to improved technical efficiency. The development of the manufacturing sector should be a major focus of industrial policy so as to encourage the production and use of local manufacturing equipment that may contribute to the efficiency of the firms. Policy should be driven to consolidate the industry to reap the economies of scale, which will lead to more efficiency. Concurrently, there is a need to focus on upgrading the skills and quality human resources, and the policy accompanying it. Attempts to maximize production efficiency will not be achieved without the appropriate skills of human resources.

References

Bos, J. W. B. & J. W. Kolari. (2005). Large Bank Efficiency in Europe and the United States: Are There Economic Motivations for Geographic Expansion in Financial Services? *Journal of Business*, 78(4): 1555-1592.

Bravo-Ureta, B. E. & L. Rieger. (1990). Alternative Production Frontier Methodologies and Dairy Farm Efficiencies. *Journal Agricultural Economics,* 41: 215-226.

Chen, T. & Tang, D. (1987). Comparing technical efficiency between import substitution-oriented and export-oriented foreign firms in a developing economy. *Journal of Development Economics*, 26: 277-289.

Cobb, C. & P. Douglas. (1928). A Theory of Production. *The American Economic Review*, 18, Supplement, 139-72.

Debreu, G. (1951). The coefficient of resource utilization, *Econometrica*, 19(3): 273–292.

Farrell, M. l. (1957). The Measurement of Productive Efficiency. *Journal of Royal Statistic Society Series.* 120: 253-290.

Greene, W. H. (1997). *Frontier production functions.* In M. H. Pesaran and P. Shmidt (eds.). *Handbook of Applied Econometrics*, *Volume II: Microeconometrics*. Blackwell Publishers Ltd.

Jovanovic, B. (1982). Selection and the Evolution of Industry. *Econometrica*, 50: 649-670.

Kidane, A. (2011). The Eritrean Economy: Performance, Potentials and Constraints. In Aryettee et al. *The Oxford Companion to the Economics of Africa*. Oxford University Press, 484–486.

Kidane, A. (2001). Eritrean macroeconomic performance (1992-2000). Paper presented at the International Conference on Eritrean Studies, Asmara.

Marshall, P. J., R. Sorenson, K. Brigham, E. Fieling, A. Reifman & R. S. Wampler. (2006). The paradox for the family firm CEO: Owner age relationship to succession related processes and plans. *Journal of Business Venturing,* 21: 348-368.

Hauner, D. (2005). Explaining Efficiency Differences Among Large German and Austrian Banks. *Applied Economics*, 37: 969–980.

Maudos, J., J. M. Pastor & L. Serrano. (2000). Efficiency and Productive Specialization: An Application To The Spanish Regions. *Regional Studies*, 34: 829-834.

Neff, D. L., P. Garcia & R. H. Honbaker. (1991). Efficiency Measure Using the Ray-Homothetic Function: A Multi Period Analysis. *Journal of Agricultural Economics,* 23: 113-121.

Osiewalski, J., G. Koop & M. F. J. Steel. (2000). Stochastic Frontier Analysis of Output Level And Growth In Poland And Western Economics, *Economics of Planning*, 33(3): 185-202.

Sanjeev, G. M. (2006). Data Envelopment Analysis (DEA) for Measuring Technical Efficiency of Banks. *Journal of Business Perspective*, 10(1): 14-27.

Sharma, S. C., K. & H. M. Sylwester. (2003). Technical Efficiency and Total Factor Productivity Analysis Across U.S. States: 1977-2000. Mimeo. Department of Economics, Southern Illinois University Carbondale, Illinois.

World Bank. (2010). *Eritrea Enterprise Survey*, World bank.

Worthington, A.C. (2000). Cost efficiency in Australian Non-Bank Financial Institutions: A Non-Parametric Approach. *Accounting and Finance*, 40: 75-97.