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The Relationship between Firm Size and Technical Efficiency in East Africa Manufacturing Firms

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ABSTRACT

The main objective of this study was to establish the relationship between firm size and technical efficiency in East Africa manufacturing firms. This study used a two step methodology to examine the relationships between technical efficiency and firm size in east Africa manufacturing firms. In the first step, technical efficiency measures were calculated using DEA approach. Secondly, using the GLS technique, a technical efficiency equation was estimated to investigate whether technical efficiency is increasing in firm size. Contrary to our expectation, the results showed a negative association between firm size and technical efficiency in both Ugandan and Tanzanian manufacturing firms. The existence of a positive association between size squared and technical efficiency and a negative association between firm size and technical efficiency in Ugandan and Tanzanian manufacturing firms suggests an inverted U- relationship between firm size and technical efficiency in these countries.

Keywords: Firm size, technical efficiency, manufacturing firms

INTRODUCTION

This study analyzes the relationship between firm size and technical efficiency in East Africa manufacturing firms. The relationship between firm size and technical efficiency has been, and still remains, a debatable issue. From a theoretical viewpoint, the relationship between firm size and efficiency is not clear cut (Audretsch, 1999). On one hand, it is argued that direct participation of the owner in productive activities lowers agency costs in small firms compared to large firms, where delegation gives rise to issues of potential adverse selection and moral hazard. The manager, being the "residual claimant", has an incentive to maximize profit and can help to promote loyalty as well as assisting in the emergence of efficient social conventions and behavioral norms. The environment may also favor small firms compared with large firms that may face intuitional restrictions. It is also argued that much of the focus of larger firms tend towards process, form, and bureaucracy and not toward results. Moreover, it is more difficult to keep a large firm efficient (Leibenstein, 1966).

Some researchers advocate promotion and support of small firms on the basis of both economic and welfare arguments (Young, 1991). It is argued, for instance, that an expansion of the small firm segment leads to more efficient resource allocation, less unequal income distribution, and less underemployment because small firms tend to use more labor-intensive technologies. Agell (2004) argues that employees of smaller firms may be more motivated by competitive-based incentive schemes rather than financial ones, thus possibly making small firms more efficient.

On the other hand, large firms may enjoy efficient human specialization, as well as scale economies (Williamson, 1970). The theory by Jovanovic (1982), developed as a model of firm growth, leads to the conclusion that larger firms are more efficient than smaller ones. The result is an outcome of a selection process, in which efficient firms grow and survive, while inefficient firms stagnate or exit the industry. Although the Jovanovic model has been developed in various directions, for instance by Hopenhayn (1992) and Ericson and Pakes (1995), the basic prediction of a positive size-efficiency relationship remains. On the basis of these analytical arguments, no clear-cut conclusion seems to emerge about the association between firm size and technical efficiency.

Should industrial policy be neutral with respect to size, or favor a certain size category of firms? Despite this unanswered question, few studies have evaluated the effect of firm size on the technical efficiency of manufacturing firms in east Africa. Lack of firm level data has hampered progress in this research area. From a policy perspective, empirical evidence on the size-efficiency relationships may prove useful in order to direct resources to firms, which employ them more efficiently.

There are now many studies that analyze efficiency and size relationship based on firm-level data sets(see Pitt and Lee, 1981; Martin and Page, 1983; Corbo and P. Mellor, 1979; Chen and Tang, 1987; Tybout, 1991; Clerides et al., 1998; Lundvall , 1999). The Jovanovic model has been put to empirical test in studies of firm growth by Evans (1987), Hall (1987), and Dunne, Roberts and Samuelson (1989) on US data, and by MacPherson (1996) on Sub-Saharan data. Firm size appears to have either a positive or a zero correlation with technical efficiency. The only exception to this pattern was presented in the Biggs, Shah and Srivastava (1996) study, where an inverted U-shaped association between firm size and efficiency was estimated. Hence, the size-efficiency relationship was negative for large firms and positive for small firms. The pattern was detected in three of the four sectors, where medium-sized firms (50-199 workers) are the most efficient. Lundvall and Battesse (2000) provide a comprehensive review of empirical literature on technical efficiency and size relationship. The findings suggest that the relationship between firm size and technical efficiency is mixed.

This study is motivated by existing empirical research gap on effect of firm size on efficiency of manufacturing firms in the east African countries. Studies that have focused on firm size and firm efficiency have produced conflicting results. This study, therefore, seeks to contribute some useful input into the debate on the association between firm size and technical efficiency. An understanding of this process is important from a policy perspective because it provides information relevant to policy design for industry specific strategies. The remaining part of this paper is structured as follows. The next section describes the theoretical framework. The third section describes the methodology. The fourth section discusses the results. The last section concludes.

THEORETICAL FRAMEWORK

In the neo-classical theory, firms of different sizes are not expected to operate at different levels of technical efficiency. The size of a competitive firm may be determined as the minimization of the average cost of production for the best-practice frontier; however, deviations from it are basically left unexplained. As Lovell (1993) points out, "the identification of the factors that explain differences in efficiency is essential for improving the results of firms although, unfortunately, economic theory does not supply a theoretical model of the determinants of efficiency".

According to Caves and Barton (1990) and Caves (1992), several studies have developed a strategy for identifying the determinants of efficiency. These determinants include: factors external to the firm (i.e., competition); characteristics of the firm (i.e., size, ownership, and location); and dynamic disturbances (i.e., technical innovation). Technical efficiency can be related to the scale or size of firm if, as according to Torii (1992), it is assumed that maintaining or improving efficiency demands a cost in terms of the firm's management, or in other words, a cost of determining how much should be invested in preserving the firm's results. According to Caves (1992), this cost is not proportional to the firm's output, but on the contrary, the larger the size of the firm, the lower the unit cost in terms of the firm's management.

Efficiency plays a significant role in the growth and dissolution of firms in the literature on firm growth. The Jovanovic (1982) model, which incorporates elements from the stochastic and the entrepreneurial theories of firm growth, can be used to analyze relationships between firm size and efficiency. The Jovanovic model assumes a competitive industry, with a known time-path of future output prices, where firms differ in efficiency. Total costs are $\varphi c(y)$, where $c(y)$ is a cost function common to all firms and $\varphi>0$ is a firm-specific fixed inefficiency parameter. The static profit-maximization problem facing firms is;

$$Max\ \pi = py - \varphi * c(y) \qquad (1)$$

Where, $\varphi*$ is the firm's expectation of φ conditional on the information available to the firm. The change in profit-maximizing output, given a change in φ^*, is;

$$\partial y / \partial \varphi * = c'(y) / \varphi * c''(y) \qquad (2)$$

Which is negative because costs are assumed to be convex, i.e., $c''(y)>0$. Firm size, in terms of output, is consequently positively related to efficiency. A firm considers its efficiency level as given and adjusts its scale of operation accordingly. The expressions in (1) and (2) clearly state the direction of the causality inherent in this model. That is, it is efficiency that determines firm size, and not the other way around. As a result, efficient firms grow and inefficient firms decline. The Jovanovic model has been criticized on some of its assumptions. The assumption of a fixed inefficiency parameter, for instance, assumes that there is no learning by doing. The study of learning by doing dates back to the 1930s, and since then, models have been developed to describe learning curves and their contribution to productivity growth at both sector and macro levels (Malerba, 1992). An important empirical regularity is the existence of strong diminishing returns in the 'learning-by-doing process' (Young, 1991). The literature on learning by doing thus provides a number of arguments for positive effects of experience on the efficiency parameter.

A model by Ericson and Pakes (1995) proposes another channel through which efficiency may be altered, namely through direct efficiency-enhancing investments by the firm. The outcomes of such investments are, however, uncertain and depend on a number of factors, including the behavior of competing firms. In the beginning of each period, the firms must decide whether to exit, to continue at current efficiency levels, or to invest. Entrants begin with relatively low levels of investment. Over time, firms whose investments are successful grow and invest even more, while less-fortunate firms maintain their current sizes or leave the industry. As a result, efficient firms are generally larger and older than entrants.

METHODOLOGY

In the first step, technical efficiency scores are calculated using DEAP version 2.1 computer program written by Coelli (1996). We use a one output/multi-input technology specification. For each firm, we estimate the variable to scale technical efficiency model. To estimate technical efficiency, it requires data on output and input quantities. However, since most data sets are given in value terms, researchers use real monetary values as proxies for quantity (Karamagi, 2002). For each firm, we obtained data on output, capital, labor, and raw materials, including energy. The values of variables used in the empirical analysis in this study are obtained from this data and are defined as follows. *Output* is the value of all output produced by the firm in a year. We consider three inputs in our estimation of technical efficiency scores. *Capital* is defined as the replacement cost of existing machinery and other equipment employed in the production process, multiplied by the degree of capacity utilization. *Wages* is the total wage bill, including all allowances, for the firm in one year. *Intermediate inputs* include costs for raw materials, solid and liquid fuel, electricity, and water. These input and output definitions have now become standard in the literature on productivity analysis (see Scully, 1999; Lundvall,1999; Chapelle and Plane, 2005; Brada, King and Ma,1997; Little, Mazumdar and Page,1987; Page,1984). It is assumed that firms face the same input and output prices.

There exists no well-grounded methodological framework to analyze the determinants of technical efficiency, possibly because of the difficulties involved (Lundvall, 1999). Karamagi (2002) argues that the choice of the variables to include in the technical efficiency model is justified by common reasoning. Since economic theory does not offer us a model to explain the relationship between efficiency and firm size, the study does not aim to find causal relations but only correlations between efficiency and firm size and a set of exogenous variables that have been shown to explain efficiency in previous studies.

Different regression models have been used by previous researchers for the second-step analysis of the technical efficiency equation. These include OLS (Nyman and Bricker, 1989; Dijk and Szirmai, 2006), Tobit (McCarty and Yaisawarng, 1993; Kooreman, 1994) and the logistic regression model (Ray, 1988). The dependent variable technical efficiency (TE) is a fractional variable bounded between zero and one with a mass point at one corresponding to the population of frontier firms. Therefore, using efficiency as the dependent variable directly in ordinary least squares estimation yields estimates that are asymptotically biased toward zero (Kooreman, 1994). In the Tobit-studies, the choice of model is motivated on the idea that efficiency can be regarded as censored, which implies that there exists a latent variable that can take values greater than one. The Tobit model is appropriate when it is possible for the dependent variable to have values beyond the truncation point, yet those values are not observable (McCarty and Yaisawarng, 1993). However, the presence of a latent variable in the Tobit model is not consistent with the definition of the frontier. For practical considerations, the logistic regression models cannot be employed when the sample includes fully efficiency firms, that is, when technical efficiency is equal to one, which indeed always is the case for DEA (Lundvall, 1999).

To solve for the boundary problem, two methods have been used in the empirical literature. The first one uses scale factors to transform technical efficiency scores (Lundvall, 1999). The second one applies the logistic transformation (ln [TE/ (1-TE]) to make technical efficiency continuous (Ramanathan, 1989). Since the scaling approach is arbitrary, we adopt the logistic transformation approach. We use Generalized Least Squares to estimate the technical efficiency equation.

The technical efficiency equation that is estimated is defined as follows for observation (firm) *i* in period *t*:

$$Y_{it}^{*} = \beta X_{it} + \alpha Z_{it} + v_i + \epsilon_{it} \qquad (3)$$

Where x_i is a vector of independent exogenous control variables hypothesized to be correlated with efficiency, *Z* is the firm size. *Firm size* is proxied by the total number of employees, being the average of permanent and temporary workers employed. ϵ_{it} are unobserved components affecting the firm technical efficiency, which does change overtime, v_i are time constant factors affecting technical efficiency. We assume that unobserved errors are uncorrelated and there is no autocorrelation overtime and cross individual units for each kind of error. β is a vector of unknown parameters, and α is the coefficient on firm size, which is hypothesized to be positive, and y_i is the technical efficiency score. The firm specific exogenous variables that we include in our specification include; firm age, foreign ownership, export participation, sector effects, and firm location. *Location* is measured by a dummy variable equal to one for manufacturing firms located in a given main town and zero otherwise. The main capital city is used as the base category. *Export participation* is captured by a dummy variable for firms participating in export market and zero otherwise. *Foreign ownership* is defined as the percentage of ownership of a firm by a foreign citizen. *Firm age* is the actual years the firm has been operating in the country since it was established. *Sector effects* are captured by textiles, wood products and furniture, metal work and machinery, chemicals, and others sector dummies. The agro based sector is used as our base category.

The selection theory predicts that technical efficiency is positively related to firm age. New firms are unaware of their abilities and need time to decide on their optimal size. Overtime the least-efficient firms exit, leaving a more efficient population of firms for every given age category. The literature on learning, which is related to the literature on endogenous growth theory, industrial organization, and trade theory, also argues that firms become more efficient as a result of its growing stock of experience in the particular industry. We expect a positive association between firm age and technical efficiency. We also include size squared to investigate whether there in an inverted-U relationship between technical efficiency and firm size. The new economic geography theory suggests that firms will benefit if they can produce in nearby locations. This may generate some agglomeration effect that enhances the efficiency of the firms (Fujita and Thisse, 2002).

There are four major problems associated with using DEA technical efficiency scores as the dependent variable in the second step analysis. The first one is concerned with how to separate the independent variables as either inputs or determinants of efficiency. The second issue concerns the inputs and determinants that may be correlated and so cause biased and inconsistent estimates in either step. The third concern is the issue of unobservable determinants of efficiency, such as management abilities. Lastly, the distribution of efficiencies is confined between zero and one with a mass point at one corresponding to the population of frontier firms. Thus, using efficiency as the dependent variable in a regression model may cause problems. The first two concerns are addressed by considering mainly exogenous variables as the independent variables. This rules out any correlation among determinants and inputs. For potential endogenous variables, such as size and export participation, we use their first lag as their instruments. The third issue is addressed by estimating a random effect regression model since it captures effects of unobservable determinants in the error term. The last issue is addressed by logistic transformation (ln [TE/(1-TE]) to make technical efficiency continuous (Ramanathan, 1989).

Since economic theory does not offer us a model to explain the relationship between efficiency and firm size, the study did not aim at finding causal relations, but only correlations between efficiency and firm size. The theoretical literature on firm size and technical efficiency suggests that firm size influences efficiency positively. We, therefore, test the hypotheses that firm size is positively associated with technical efficiency.

Data sources

The analysis contained in this study was based on a sample of agricultural manufacturing firms across Kenya, Tanzania, and Uganda. The data used in this study was obtained from survey data that was collected from an interview during 2002- 2003 by World Bank as a part of the Investment Climate Survey in collaboration with local organizations in east Africa. The collaborating institutions for the design and enumeration of the east African surveys were the Kenya Institute for Public Policy Research (KIPPRA), the Economic and Social Research Foundation–Tanzania (ESRF), and the Uganda Manufacturers' Association Consulting Services (UMACIS).

The sampling strategy was standardized across the East African surveys. The firms were randomly selected from a sampling frame constructed from different official sources and stratified by size, location, and industry. Investment climate surveys were completed in the three East African countries almost at the same time. The relevant sample included all manufacturing firms that had complete data on all variables of our interest. This was around 403 firms. Although the data are not strictly comparable to surveys in other countries, useful comparisons were made between the results obtained from the survey data and those obtained in other African countries.

REGRESSION RESULTS

There are two main estimation techniques used in the panel data analysis: random effect and fixed effect. The Hausman specification test, proposed by Hausman (1978), which is based on the difference between the fixed and random effects estimators, is usually used in order to decide whether to use fixed or random effects model. A rejection of the null hypothesis leads to the adoption of the fixed effects model and non rejection leads to the adoption of the random effects model (Baltagi, 2005). This study used both the fixed and random effect techniques to estimate the technical efficiency equation. Regression results of the technical efficiency equation (3) are reported in Table 1.1. A Hausman test in all the estimations led to non rejection of the null hypothesis, which showed a P-value greater than 10 percent, implying that there was insufficient evidence to reject the null hypothesis (see Table 1.1).

Table 1.1 : Determinants of technical efficiency: GLS Random Effects Estimates

Dependent variable: Ln (Transformed Technical Efficiency Scores)

	Kenya	Tanzania	Uganda
Constant	-.477(-.72)	-1.038(-1.15)	-.189(-.34)
Export dummy $_{t-1}$	-.0353(-.17)	.142(.48)	.615(1.99)**
Ln(size) $_{t-1}$	.014(.17)	-.258(-2.14)**	-.363(-4.90)***
In(size^2) $_{t-1}$	.0588(1.19)	.137(2.38)**	.112(1.89)*
Ln(firm age)	-.172(-1.44)	.216(1.48)	-.075(-.71)
Ln(firm age^2)	-.0595(-1.45)	-.109(-1.32)	-.0567(-1.17)
Foreign ownership	.00758(2.29)**	.00758(2.29)**	-.0029(-.99)
Chemicals dummy	.850(2.32)**	.545(1.04)	-.694(-1.74)*
Textiles dummy	.0332(.12)	1.158(2.01)**	.483(1.12)
Metals dummy	-1.159(-4.45)*	.684(1.14)	-.646(-1.65)*
Furniture dummy	1.428(3.66)*	.109(.24)	.602(2.34)**
Other sectors	.541(1.22)	.796(2.51)***	-.716(-3.05)***
City location dummy1	-.345(-1.08)	-.310(-.59)	.0139(.06)
City location dummy2	.116(.19)	-1.189(2.46)*	
City location dummy3	-.263(-1.02)	-1.535(-2.98)*	
City location dummy4	-.107(-.30)	-.947(-2.45)*	
R-sq- Within	.0017	.0854	.0006
Between	.341	.179	.292
Overall	.25	.164	.172
No. of observations	281	274	417
Hausman test			
Chi2	3.36	16	1.40
Prob>chi2	.998	1.00	.999

*Note: ***, ** and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively. Values in brackets are robust Z-statistics. City Location: Tanzania: 1=Arusha, 2=Tanga, 3=Mwanza, 4=other cities; Kenya: 1=Eldoret, 2=Kisumu, 3=Mombasa, 4 =Nakuru ; Uganda: 1=South West, 2=North East.*

Contrary to our expectation, the results showed a negative association between firm size and technical efficiency in both Ugandan and Tanzanian manufacturing firms, a result that was consistent with findings by Biggs, Shah and Srivastava(1996). If small firms benefit from less regulatory obstacles, the arguments proceeding from the property rights and agency cost theories are not rejected. It is also possible that small firms, due to their flexibility and simplicity of organizational structures and decision making process, make them more efficient than large manufacturing firms in Uganda and Tanzania. The existence of a positive association between size squared and technical efficiency and a negative association between firm size and technical efficiency in Ugandan and Tanzanian manufacturing firms suggests an inverted U- relationship between firm size and technical efficiency in these countries. An inverted U-relationship can be interpreted to mean that technical efficiency increases until a firm size threshold is reached and technical efficiency decreases with an increase in the firm size. Hence, the size efficiency relationship is negative for large firms and positive for small firms. The association between firm size and technical efficiency in manufacturing firms in Kenya was not significant. This result was consistent with some previous studies (Chen and Tang, 1987; Page, 1984).

Foreign ownership was shown to be positively related to technical efficiency in Kenyan manufacturing firms. This result was consistent with the long held view that foreign ownership is believed to be a vehicle for the international transfer of management skills, technical knowhow, and market information that cannot be licensed out or transferred to clients via technical assistance arrangements (Teece Pisano, and Shuen, 1997). In Tanzania and Ugandan manufacturing firms, foreign owned manufacturing firms were not significantly, technically, efficient than the local owned firms.

In all the regressions, the association between age and technical efficiency was not significant. This was consistent with findings of previous studies (see Chen and Tang, 1987; Page, 1984; Brada, King and Ma, 1997; and Lundvall and Battesse, 2000, but not with a positive age-efficiency relationship, as proposed by Jovanovic (1982). Literature on learning argues that firms become more efficient as a result of its growing stock of experience in the particular industry. This may be neutralized by the fact older firms tend to employ capital of an older vintage, which is less productive than the industry average, and this leads to a technical decrease with firm age (Little, , Mazumdar and Page, 1987). This suggests that more than a selection process is reflected in the age variable. Such effects may include, for example, the gains from a growing stock of experience, and, the losses from a capital stock that becomes obsolete. The age variable may pick up the combined effect of these factors, which makes it conceptually hard to interpret (Lundvall and Battesse, 2000).

In Kenya and Uganda manufacturing firms, results showed no significant differences in technical efficiency scores between the main city and other towns. This finding was not consistent with new geography theory that emphasizes positive agglomeration effects. However, in Tanzania, results showed that, apart from Arusha manufacturing firms that showed no significant differences, the rest of the other towns manufacturing firms were less technically efficient than manufacturing firms located at Dar es Salaam.

Sector effects on technical efficiency of the east manufacturing firms are not consistent. Results show that chemical and furniture firms in Kenya are more technically efficient and metal manufacturing firms are less technically efficient than agro based manufacturing firms. In Uganda, furniture manufacturing firms are shown to be more technically efficient, textile firms that are not significantly different and the rest of the manufacturing firms in other sectors are less technically efficient than the agro based firms. In Tanzanian manufacturing firms, all sectors were shown not to be significantly different from agro based manufacturing firms.

CONCLUSION

This study used a two step methodology to examine the relationships between technical efficiency and firm size in east Africa manufacturing firms. In the first step, technical efficiency measures were calculated using DEA approach. Secondly, using a GLS technique, a technical efficiency equation was estimated to investigate whether technical efficiency is increasing in firm size. The evidence did not support this claim with respect to firm size.

Contrary to our expectation, the results showed a negative association between firm size and technical efficiency in both Ugandan and Tanzanian manufacturing firms, a result that is consistent with findings by Biggs, Shah and Srivastava (1996). If small firms benefit from less regulatory obstacles, the arguments proceeding from the property rights and agency costs theories are not rejected. It is also possible that small firms, due to their flexibility and simplicity of organizational structures and decision making processes, make them more efficient than large manufacturing firms in Uganda and Tanzania. The existence of a positive association between size squared and technical efficiency and a negative association between firm size and technical efficiency in Ugandan and Tanzanian manufacturing firms suggests an inverted U- relationship between firm size and technical efficiency in this country. Hence, the size efficiency relationship is negative for large firms and positive for small firms. The association between firm size and technical efficiency in manufacturing firms in Kenya was not significant.

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