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How do Vietnamese SMEs perform? Technical efficiency of SMEs in the manufacturing sector and its sub-sectors

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Abstract

This paper evaluates the technical efficiency performance of Vietnamese manufacturing small and medium enterprises (SMEs) over the period 2002 to 2007. Using firm level data from three surveys in 2002, 2005 and 2007 with a total of 5,204 observations of domestic non-state manufacturing SMEs the paper assesses the technical efficiency level of SMEs for the aggregate manufacturing sector and separately for nine subsectors including: (i) Food and Beverages; (ii) Textiles, Garments and Footwear; (iii) Electrical and Electronic Equipment (iv) Wood and Furniture Products; (v) Chemical, Rubber and Plastic Products; (vi) Paper, Printing and Publishing; (vii) Metal Products; (viii) Non-metallic Products; and (ix) Machinery and Equipment. Results from the estimation of a stochastic frontier production function, an econometric approach to evaluate technical efficiency, reveal that Vietnamese non-state manufacturing SMEs in aggregate have relatively high average technical efficiency. Their technical efficiency reached an average level of 89.71 percent for the three surveys in 2002, 2005 and 2007. They have mean technical efficiencies of 84.25 percent, 92.55 percent, and 92.34 percent of the best practice frontier in 2002, 2005 and 2007, respectively. The results indicate that these firms can increase their current level of output by almost 15.7 percent in 2002, by about 7.5 percent in 2005 and by 7.7 percent in 2007 with the same level of inputs. The sub-sector analysis shows that technical efficiency ranges from 70 percent to 100 percent - or full technical efficiency, across sub-sectors in the 2002 – 2007 period. It is found that the high-tech Electronics and Electrical Equipment subsector has the lowest mean technical efficiency level of around 80 percent for the three surveys. The low-tech Wood and Furniture sub-sector consistently performs with full technical efficiency. Although the period examined is limited to only 5 years, there is evidence that technical efficiency increased over the 2002 – 2007 period. The findings from this study provide empirically-founded policy recommendations to improve efficiency and competiveness of Vietnamese manufacturing SMEs.

Keywords

Vietnamese, SMEs, perform, Technical, efficiency, SMEs, manufacturing, sector, its, sub, sectors

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How Do Vietnamese SMEs Perform?
Technical Efficiency of SMEs in the Manufacturing Sector and Its Sub-sectors

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Abstract

This paper evaluates the technical efficiency performance of Vietnamese manufacturing small and medium enterprises (SMEs) over the period 2002 to 2007. Using firm level data from three surveys in 2002, 2005 and 2007 with a total of 5,204 observations of domestic non-state manufacturing SMEs the paper assesses the technical efficiency level of SMEs for the aggregate manufacturing sector and separately for nine sub-sectors including: (i) Food and Beverages; (ii) Textiles, Garments and Footwear; (iii) Electrical and Electronic Equipment (iv) Wood and Furniture Products; (v) Chemical, Rubber and Plastic Products; (vi) Paper, Printing and Publishing; (vii) Metal Products; (viii) Non-metallic Products; and (ix) Machinery and Equipment. Results from the estimation of a stochastic frontier production function, an econometric approach to evaluate technical efficiency, reveal that Vietnamese non-state manufacturing SMEs in aggregate have relatively high average technical efficiency. Their technical efficiency reached an average level of 89.71 percent for the three surveys in 2002, 2005 and 2007. They have mean technical efficiencies of 84.25 percent, 92.55 percent, and 92.34 percent of the best practice frontier in 2002, 2005 and 2007, respectively. The results indicate that these firms can increase their current level of output by almost 15.7 percent in 2002, by about 7.5 percent in 2005 and by 7.7 percent in 2007 with the same level of inputs. The sub-sector analysis shows that technical efficiency ranges from 70 percent to 100 percent - or full technical efficiency, across sub-sectors in the 2002 – 2007 period. It is found that the high-tech Electronics and Electrical Equipment sub-sector has the lowest mean technical efficiency level of around 80 percent for the three surveys. The low-tech Wood and Furniture sub-sector consistently performs with full technical efficiency. Although the period examined is limited to only 5 years, there is evidence that technical efficiency increased over the 2002 – 2007 period. The findings from this study provide empirically-founded policy recommendations to improve efficiency and competiveness of Vietnamese manufacturing SMEs.

Keywords: manufacturing small and medium enterprises, firm performance, technical efficiency, stochastic frontier production function, sub-sector analysis, Vietnam.

1. INTRODUCTION

Most Vietnamese enterprises are small and medium enterprises (SMEs). They were first officially defined in 2001 as enterprises with fewer than 300 workers or a registered capital of less than 10 billion VND (about US$630,000 at the time). A more recent definition, which became effective from 20 August 2009, provides a definition for each economic sector. It changes the capital clause from registered capital in the earlier definition to total capital of up to 100 billion VND (about US$5.6 million at the time) while the upper limit for employees remains at 300 for the Agriculture, Forestry and Fishery sector, and Industry and Construction sector and reduces to 100 workers for the Services sector. Of the 155,771 formally registered enterprises in operation in 2007, SMEs accounted for 97.4 percent of total enterprises according to the employee criterion or 84.7 percent according to the registered capital criterion in the definition in 2001.

After the introduction of an economic reform program known as *Doi Moi* in 1986, the Company Law and Private Enterprise Law were passed in 1990 and 1991. With the implementation of these laws, registrations of domestic private enterprises increased steadily from 1992 (Figure 1). New business registrations were mostly in the private sector. Between 1992-1999 the private sector grew at 24 percent per annum (Steer, 2001:4). Although this growth rate was high, it started from a small base. By the end of 1999, a total of 45,000 enterprises had been established. This is a modest number given the size of the population and in comparison to other countries in the region. Despite the official recognition of the private sector under the laws, the newly emerged non-state SMEs faced several major obstacles in the 1990s, including institutional weakness, capital shortage, limited access to markets, technical and management

limitations, and unfavourable public attitudes (Le Cong Luyen Viet, 2001). Furthermore, during the 1990s, state-owned enterprises were politically favoured and the development strategy was focussed on import substituting. Meanwhile, the private sector had weak management and capital generation ability in the early period after *Doi Moi*. All of these had their influence on the growth of the private sector in the 1990s (Webster, 1999; Webster and Taussig, 1999).

However, Figure 1 also shows that the growth in registration of new enterprises since 2000 has been strong. This comes as a result of the new Enterprise Law (EL) which became effective in 2000. This important law combined the earlier Company Law and Private Enterprise Law into one law. Thus, it provided the legal framework for all types of domestic private enterprises. The EL contains an important innovation with a principle often referred to as "to register first, then to "check" by the business community (World Bank, 2005). This represents a fundamental shift in the approach and tools with which the government manages enterprises. The EL has also revitalized entrepreneurship and strengthened the trust of investors and entrepreneurs in the reforms and policies initiated by the Government (Vo Tri Thanh and Nguyen Tu Anh, 2006). According to statistics from the National Business Information Centre, more than 414,000 enterprises have been established from 2000 to 2009, which is more than nine times the number of registrations for the 1991 - 1999 period. Thus, the cumulative number of business registrations during 1992 - 2009 reached almost 460,000 enterprises. At the current rate of growth, it is expected that total business registrations will reach about 540,000 in 2010 surpassing the target to have 500,000 business registrations by 2010, set under the SME Development Plan 2006-2010, by eight percent.

This paper evaluates the performance of Vietnamese SMEs over the period 2002 to 2007. In particular, the paper examines the technical efficiency of manufacturing SMEs using firm level data from three surveys in 2002, 2005 and 2007 with 6,619 observations. The paper is structured as follows. Section 2 below provides a brief overview of the Vietnamese manufacturing sector and its technical efficiency performance estimated by previous studies. Section 3 explains the methodology, the stochastic frontier production function (SFPF) model, an econometric model used to estimate technical efficiency, and the data. Section 4 presents and discusses the estimation results for manufacturing SMEs in aggregate and nine individual sub-sectors within the manufacturing sector. Section 5 concludes the paper and provides some policy recommendations.

2. SMES IN THE MANUFACTURING SECTOR

The manufacturing sector makes an important contribution to Vietnam's economy, accounting for 21.10 percent of total GDP. In addition, manufacturing is arguably the most important field of business in Vietnam, due to the sector's ability to generate employment and exports (MPI, 2006). Table 1 presents some data about formally registered manufacturing SMEs in operation in Vietnam from 2000 – 2007. The table shows that SMEs accounted for almost 92 percent of all manufacturing firms in operation in 2007. This represents a slight increase from 88 percent in 2000. The three largest sub-sectors among manufacturing SMEs in 2007 are food and beverage processing, metal products and wood processing. These three sub-sectors accounted for almost 40 percent of total manufacturing SMEs.

Manufacturing SMEs are also more export-oriented compared to SMEs in other sub-sectors. Around 17 percent of manufacturing SMEs across different types of ownership

were involved in export activities according to data from the Enterprises Census 2000 - 2005 (Table 2).

It is clear from the discussion above that SMEs in Vietnam have undergone significant developments in recent years under economic reforms, especially in terms of number of registrations. However, what is not clear is the quality of their growth in terms of the performance of Vietnamese SMEs. Recently, there has been a growing number of studies examining the technical efficiency performance of Vietnamese SMEs in different ownership sectors and industries (Vu Quoc Ngu, 2003; Nguyen Thang et al., 2005; Rand and Tarp, 2006; Ha Viet Hoang and Carlin, 2007; Nguyen Khac Minh and Giang Thanh Long, 2007; Nguyen Khac Minh et al., 2007; Tran Thi Bich et al., 2008; Pham et al., 2009).

Because these studies examine different datasets covering different industries at different periods of time and technical efficiency is measured against the best practice production frontier derived from the respective samples, there has not been a consistent picture on the technical efficiency performance of Vietnamese SMEs. Table 3 summarises the results of some studies about the technical efficiency of Vietnamese manufacturing firms.

The first study of the technical efficiency of Vietnamese firms is a study by Vu Quoc Ngu (2003), which focused on SOEs in the three major cities of Hanoi, Hai Phong and Ho Chi Minh city. It found that manufacturing SOEs achieved a relatively high level of efficiency in 1997 and 1998, reaching almost 79 percent of the production frontier. He also found a slight improvement of the technical efficiency level in 1998 compared with 1997. Some other studies found very similar results. For example,

Nguyen Thang et al. (2005) reported that the technical efficiency level was 79.2 percent for firms in the textiles sub-sector and 81.5 percent for firms in the garments sub-sector in the 1997 – 2000 period. Tran Thi Bich et al.(2008) found that the technical efficiency level for manufacturing SMEs in the non-state sector was 79.6 percent in 1996 and 86.7 percent in 2001.

A study of Vietnamese manufacturing SMEs by Rand and Tarp (2006:22) found that the technical efficiency level of Vietnamese firms is in the same range as that found in other developing countries. They used enterprise survey data for 1990/1991, 1995/1996 and 2000/2001 and estimated average technical efficiency at around 61 percent (Rand and Tarp, 2006:22). They concluded that Vietnamese manufacturing firms are at the lower end of the range for developing countries, at 60 – 70 percent of best practice as reported by Tybout (2000). A similar result is also found in another more recent study which estimated the technical efficiency level for Vietnamese manufacturing firms in 2003 at 62 percent (Pham et. al., 2009).

The third group of studies reported the technical efficiency level for Vietnamese firms at around 50 percent of the best practice production frontier. Using panel data for 1,492 manufacturing firms from the Enterprises Census conducted in 2000-2003 by the GSO, Nguyen Khac Minh et al. (2007:31) found the average efficiency of manufacturing SMEs to be 39.9 percent and 49.7 percent when using the DEA and SFPF approaches, respectively. Two other studies using DEA also reported a low level of technical efficiency for Vietnamese manufacturing firms. Nguyen Khac Minh and Truong Tri Vinh (2007) found that technical efficiency for manufacturing firms in 2001 – 2003 was only 47.5 percent while Ha Viet Hoang and Carlin estimated technical

efficiency for Vietnamese manufacturing enterprises during the 2001 – 2005 period in the range of 45 – 53 percent depending on their type of ownership.

In summary, analyses of studies about technical efficiency and productivity growth in Vietnam have shown that that there is a variation of the technical efficiency level across sub-sectors within the manufacturing industries, by size of firms, and by ownership of firms.

3. METHODOLOGY, ECONOMETRIC MODELS AND DATA

Productivity and efficiency represents the economic aspects of firm performance. Growth in efficiency and productivity is the most important aspect of growth as it focuses on the quality of growth. For this reason theoretical and empirical works on firm performance focus on measuring enterprise productivity and efficiency (Storey, 1990).

Average labour productivity had been used as a measure of efficiency until Farrell (1957) introduced a method to measure efficiency in his seminal paper. Farrell's efficiency measure contains an efficient production frontier which is the output that a perfectly efficient firm could obtain from any given combination of inputs. The performance of a productive unit will be measured against that efficient frontier (Farrell, 1957:254).

Figure 2 explains Farell's efficiency measure. With constant returns to scale the isoquant *YY'* is the efficient production frontier. The isoquant represents the minimum set of inputs per unit of output needed to produce a unit of output. Every package of inputs along the isoquant is considered as technically efficient while any point above it and to the right, such as point *P,* is defined as technically inefficient. The technical

efficiency level is represented by *OR/OP* in Figure 2. Meanwhile allocative efficiency of the producer at point P is given as the ratio of *OS/OR*. In this case the isocost-line *CC'* reflects the objective of cost minimisation. Thus, *R'* is the technically and allocatively efficient point. The overall efficiency (which is also called economic efficiency) is equal to *OR/OP x OS/OR = OS/OP* (Murillo-Zamorano, 2004).

According to Kalirajan and Shand (1999:152) a measure of technical efficiency in the *i*th firm can be defined as:

$$TE = \frac{Y_i}{Y_i^*} \tag{1}$$

where:

Y_i: Actual output

Y^*_i: Maximum possible output

The above equation is the basic model used for measuring technical efficiency. The actual output is observable in this equation. However, maximum possible output is not observable and must be estimated. A ratio of one in the above equation would mean that the firm is technically efficient and operates on the production frontier.

A number of techniques have been developed to estimate this frontier. Several authors broadly classified them into two main groups: parametric and non-parametric (Kalirajan and Shand, 1999; Kumbhakar and Lovell, 2003; Murillo-Zamorano, 2004; Coelli et al., 2005). The parametric method uses an econometric technique by specifying a stochastic production function which assumes that the error term is composed of two elements. One is the typical statistical noise which represents randomness. The other represents technical efficiency which is commonly assumed in

the literature to follow a one-sided distribution (Alvarez and Crespi, 2003; Murillo-Zamorano, 2004).

On the other hand, the non-parametric approach does not distinguish between technical efficiency and statistical noise. It is, therefore, considered as a non-statistical technique as the inefficiency scores and the envelopment surface are ‘calculated’ rather than estimated. The non-parametric approach is often associated with Data Envelopment Analysis (DEA) which is based on a mathematical programming model to estimate the optimal level of output conditional on the amount and mix of inputs (Murillo-Zamorano, 2004). A comparison of the stochastic frontier and DEA frontier is given in Figure 3.

In the context of this study the stochastic frontier production function approach is most relevant. The first reason is the ability of the stochastic frontier approach to consider both factors beyond the control of the firm and firm-specific factors, and hence it is closer to reality. The second reason is the separation of the random variation of the frontier across firms, the effects of measurement error and other random shocks from the effect of inefficiency.

The stochastic frontier production model was developed independently and simultaneously by Aigner, Lovell and Schmidt (ALS) (1977), Meeusen and Van den Broeck (MB) (1977), and Battese and Corra (1977). In this model there is a composed error term which captures the effects of exogenous shocks beyond the control of the analysed units in addition to incorporating technical inefficiency. Errors in measurement of outputs and observations are also taken into consideration in this model (Kumbhakar and Lovell, 2003; Murillo-Zamorano, 2004).

The generalised functional form in the Cobb-Douglas case of the stochastic production function can be specified as:

$$Y_i = x_i\beta + (V_i + U_i), \qquad i = 1, \ldots, N, \qquad (2)$$

where

Y_i is the production (or the logarithm of production) of the *i-th* firm;

x_i is a $k \times 1$ vector of (or transformation of) the input quantities of the *i-th* firm;

β is a vector of unknown parameters;

V_i are random variables which are assumed to be independently and identically distributed (*iid*) as $N(0, \sigma_v^2)$,[1]

U_i which are non-negative random variables that are assumed to account for technical inefficiency in production and are often assumed to be *iid*. $|N(0, \sigma_u^2)|$. It is assumed to be half-normal, exponential and truncated from below at zero.[2]

The maximum likelihood method can be used to estimate the coefficients of the above production function. The likelihood function is expressed in terms of the variance parameters of the frontier function:

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[1] This means that the errors are independently and identically distributed normal random variables with zero means and variances σ^2.

[2] U_i reflects one-sided deviations of actual output from the maximum level of production due to technical inefficiency. If a firm is fully technically efficient, $U_i=0$, otherwise it will be greater than zero. Thus, it is also called a one-sided error component.

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \text{ and } \gamma = \frac{\sigma_u^2}{\sigma^2} \tag{3}$$

where

σ_v^2 is variance of noise and

σ_u^2 is variance of inefficiency effects.

If the value of σ^2 is equal to zero, then u_i is also zero which means the firms are fully efficient. γ has a value between one to zero. If the value of γ is zero, the deviations from the frontier are attributed to random error. If it has the value of one, the deviations are due to technical inefficiency.

A software package which is most commonly used in the estimation of stochastic production frontiers in the literature is FRONTIER 4.1 developed by Coelli (1996). The software program carries out three steps of estimation. The first step is Ordinary Least Squares (OLS) estimates of the production function. It provides unbiased estimators for all the β except the intercept. The OLS estimates are then used as starting values to estimate the final maximum likelihood model. The second step carries out a two-phase grid search of the value of the likelihood function which is estimated for different values of γ with the β parameters derived in the OLS. The third and final step calculates the final maximum likelihood estimates (MLE) with an iterative Davidon-Fletcher-Powell algorithm. This step uses the values of the βs from the OLS and the value of γ from the intermediate step as starting values (Coelli, 1996).

There are several choices of functional form for the production frontier. The most common functional forms for the stochastic frontier production function are the

Cobb-Douglas production function and the Transcendental-logarithm (Translog) production function. A hypothesis test is conducted to choose the functional form for the stochastic frontier production function:

$$H^1_0: \beta_4=\beta_5=\beta_6=\beta_7=\beta_8=\beta_9=0 \qquad (4)$$

The results of this test are presented in Table 4, which reveals that the Translog specification is most appropriate for this study with the exception of the Wood and Furniture and the Non-metallic sub-sectors in 2002. The Translog stochastic production function can be expressed as follows:

$$\begin{aligned} \ln Y_i &= \beta_0 + \beta_1 \ln K_i + \beta_2 \ln L_i + \beta_3 \ln ME_i \\ &\quad + \beta_4 (\ln K_i)^2 + \beta_5 (\ln L_i)^2 + \beta_6 (\ln ME_i)^2 \\ &\quad + \beta_7 \ln K_i \ln L_i + \beta_8 \ln K_i \ln ME_i + \beta_9 \ln L_i \ln ME_i + V_i + U_i \end{aligned} \qquad (5)$$

where:

Y_i = Output of firm i

K_i = Value of Capital of firm i

L_i = Labour input of firm i

ME_i = Value of Materials and Energy for firm i

V_i = Random error in which $v_i \sim N(0, \sigma^2_v)$

U_i = Technical Inefficiency in which $u_i \sim N(\mu_i, \sigma^2_u)$

The second line of Equation (5) includes the squared terms of the input factors, while the third line expresses the interaction terms among the inputs.

This study uses recent firm-level data from three comprehensive and large-scale surveys of Vietnamese small and medium enterprises in 2002, 2005 and 2007. The

surveys were carried out by the Vietnamese Institute for Labour Studies and Social Affairs (ILSSA) in Hanoi with the assistance of international counterparts from Sweden and Denmark. The first round of the survey was supported by the Swedish International Development Authority (SIDA) and the remaining ones were assisted by the Danish International Development Agency (DANIDA).[3]

The surveys provide a valuable set of data about private sector SMEs in Vietnam. The surveys were implemented after the important Enterprise Law of 2000 was introduced. They contain the most comprehensive data about SMEs in Vietnam. Although other surveys have a larger coverage, they do not focus on SMEs.[4] In addition, the focus on domestic non-state and manufacturing SMEs in the survey make it the only dataset available about this most important sector for SMEs in Vietnam. The surveys also had coverage in different regions of Vietnam, including urban and rural areas. The sample was stratified to ensure that different types of ownership were represented based on the overall distribution of ownership in the population of domestic non-state enterprises. In total, 6,619 enterprises from different sub-sectors in manufacturing industries were interviewed in the three survey rounds.

From the raw data obtained in the surveys described above, data for analysis is constructed for the domestic non-state manufacturing SMEs sector. Enterprises reporting in the survey that they were not in the manufacturing sector are removed from the dataset. Similarly, enterprises with missing values are also removed. After this process has been carried out, the eligible observations for analysis have been reduced to 5,204 with 926 firms in 2002, 2,228 firms in 2005 and 2,050 firms in 2007. The usable

[3] For a description of the surveys, see Rand et al. (2004), Rand and Tarp (2007), and Rand et al. (2008).
[4] They include the Industrial Censuses and Business Censuses carried out by the General Statistics Office and Business Environment and Enterprise Productivity Surveys conducted by the World Bank.

observations are classified into 9 sub-sectors according to the International Standard Industrial Classification (ISIC) codes for analysis. They are: (i) Food and Beverages; (ii) Textiles, Garments and Footwear; (iii) Electrical and Electronic Equipment (iv) Wood and Furniture Products; (v) Chemical, Rubber and Plastic Products; (vi) Paper, Printing and Publishing; (vii) Metal Products; (viii) Non-metallic Products; and (ix) Machinery and Equipment. Table 5 shows the distribution of observations for each of the nine sub-sectors.

4. RESULTS AND DISCUSSIONS

This section describes the results obtained for the aggregate manufacturing SMEs and individual sub-sectors. The description of the results below also includes some comparisons of technical efficiency levels for the sub-sector with other studies, both for Vietnam and other countries. However, the comparisons serve for illustrative purposes only, as technical efficiency is estimated based on the respective best practice frontier which is not the same across countries, industry, time period, size of enterprises or ownership type. In addition, empirical studies have different sample sizes and use different proxies for their output and input variables, depending on the availability of data. This makes a comparison of results with other studies even more futile or questionable.

Table 6 provides a summary of the results from estimation of the frontier production function with cross-sectional data from the three surveys in 2002, 2005 and 2007. The model for the stochastic frontier production function is based on production theory, with three inputs as described in Equation (5). The coefficients for labour and intermediate inputs are significant and positive for many cases. This indicates that labour and materials are important inputs in production for manufacturing SMEs in

Vietnam. Thus it suggests that Vietnamese manufacturing SMEs rely more on labour and materials to increase their output. This is worrying as the over-reliance on labour could lead to a low cost labour trap, which makes it difficult for firms to move up the value chain and increase their competitiveness.

Meanwhile, capital input is insignificant, small and negative in most cases. The same issue is found to occur in another study of Vietnamese manufacturing SMEs (Tran Thi Bich, 2008). This could be due to measurement errors, because it is difficult to have an exact measurement of the capital input for Vietnamese SMEs. There is a tendency for SMEs to under-report their activities to avoid the "tall-poppy syndrome".[5] In Vietnam, under-reporting is common for private sector SMEs to avoid paying corporate taxes and other formal fees (Steer and Taussig, 2002). This has led to the estimation that official numbers may underestimate output from the domestic private sector by 50 percent or even higher (Tenev et al., 2003). In addition, private enterprises in Vietnam often have informal land rights to their premises. This gives rise to informal transactions with three out of every four real estate transactions believed to take place in the unofficial market (Tenev et. al., 2003). Being aware of this issue, this study has attempted to get a better measurement of capital by using productive assets as the proxy for capital instead of total assets as in a previous study by Tran Thi Bich (2008).

The MLE also provides estimates of the variance parameters sigma-squared (σ^2) and gamma (γ). The first variance parameter, σ^2, determines whether there is technical inefficiency or not. The second variance parameter, γ, determines whether all deviations from the frontier are due to random error or technical inefficiency. Table 6 shows that all the variance parameters in the estimated stochastic production functions are

[5] This refers to the tendency for small enterprises to under-report their activities to avoid too much attention.

statistically significant in cases where technical inefficiency is detected. Moreover, the σ^2 parameter is significantly different from zero, ranging from 0.01 to 1.35. This suggests that all firms are not technically efficient. The value of the other variance parameter, γ, ranges from 0.3745 to 1 indicating that technical inefficiency explains 37.45 percent to 100 percent of the total variation from the frontier.

As shown in Table 7, Vietnamese non-state manufacturing SMEs operated at a high level of technical efficiency. Aggregate manufacturing SMEs have mean technical efficiencies of 84.25 percent, 92.55 percent, and 92.34 percent in 2002, 2005 and 2007, respectively. The results indicate that these firms increased their current level of output by almost 15.7 percent in 2002, by about 7.5 percent in 2005 and by 7.7 percent in 2007 with the same level of inputs. Meanwhile, technical efficiency of manufacturing SMEs in different sub-sectors ranges from 70 percent to 100 percent, which means full technical efficiency, in the 2002 – 2007 period (Table 7). The high-tech Electronics and Electrical Equipment sub-sector has the lowest average technical efficiency level of around 80 percent for the three surveys. The low-tech Wood and Furniture sub-sector has full technical efficiency across all three surveys. Because Wood and Furniture enterprises tend to use simple technology in their production they could reach the best practice frontier more easily.

The average technical efficiency for non-state manufacturing SMEs in aggregate for the study period is 89.7 percent. This result indicates that manufacturing SMEs in Vietnam can reduce their current level of inputs by 10.3 percent to achieve the same level of output during the examined period. This result is higher than the technical efficiency level of 78.9 percent estimated for state-owned manufacturing enterprises in Vietnam in 1998 (Vu Quoc Ngu, 2003), 50 percent for 1,492 manufacturing SMEs

across all types of ownership in Vietnam in the 2000-2003 period (Nguyen Khac Minh et. al., 2007) or the 62 percent level for Vietnamese manufacturing enterprises of different ownership forms and sizes in 2003 (Pham et. al., 2009). However, a direct comparison cannot be made because there are differences in the focus of the other studies in terms of firm size and ownership. Nevertheless, it is possible that the beneficial impacts of the policy measures take time to have an impact. Thus, technical efficiency is found to be higher in this study than previous studies as summarised in Table 3.

The estimated technical efficiency level found in this study is also higher than the mean technical efficiency of 62.33 percent obtained for Malaysian manufacturing SMEs during 1992-1999 by Oguchi *et al.* (2006), but is almost similar to the technical efficiency level of 87.7 percent for Thailand's industries in 1997 reported by Wiboonchutikula (2002). Compared to the mean technical efficiency at around 60 percent to 70 percent of the best practice frontier in developing countries, as reported by Tybout (2000), Vietnamese manufacturing SMEs are quite efficient. Nevertheless, as the technical efficiency of Vietnamese SMEs is estimated with regards to their best practice frontier, it is not possible to conclude that Vietnamese manufacturing SMEs are more efficient than their counterparts in developing countries.

Although this study has covered a short period of 5 years, there is an indication that the technical efficiency of manufacturing SMEs in Vietnam increased during the period examined (Table 7). SMEs in the aggregate manufacturing sector performed relatively better in 2005 than in 2002 and 2007. Most sub-sectors had higher technical efficiency in 2005 than in 2002. A possible explanation for the rise in efficiency is the impact of the Enterprise Law, which took some time to make a difference and enhance

SMEs efficiency performance. Yet, the impact of the reforms appeared to diminish in some sub-sectors as their technical efficiency in 2007 was smaller than the level in 2005. This could be due to a less favourable macroeconomic environment in Vietnam and the global economic environment in the past few years, and possible complacency on the part of the government in the reform process.

It is clear from Table 8 that firms with a technical efficiency level greater than 80 percent accounted for the majority of the firms in the aggregate manufacturing SME sample and for the manufacturing sub-sector samples. The only exception is the distribution of technical efficiency for firms in the Electrical and Electronics sub-sector in the 2005 sample, with more than three quarters of firms having technical efficiency below 80 percent. This is the case because the average technical efficiency for SMEs in this sub-sector in 2005 was about 70 percent as shown in Table 7.

5. CONCLUSIONS

The economic reforms under *Doi Moi* have led to significant development of private sector SMEs in Vietnam. From operating informally under the central planning period the sector has received formal recognition and attention because of its increasingly important role in the economy. Manufacturing SMEs in the non-state domestic sector not only create jobs but also produce for export. Although most discussion about Vietnamese private sector SMEs has focussed on the significant number of business registrations, especially after the introduction of the Enterprise Law in 2000, little has been studied about the performance of these firms. This paper addresses the gap and evaluates the economic performance of Vietnamese SMEs in the manufacturing sector using extensive firm level data from three surveys in 2002, 2005 and 2007. By estimating a stochastic frontier production function with 5,204 observations of

Vietnamese non-state domestic manufacturing SMEs, this study has empirically analysed the technical efficiency performance of these SMEs.

The results from this study indicate that Vietnamese non-state manufacturing SMEs operate at a high level of technical efficiency, both in the manufacturing sector in aggregate and in terms of sub-sectors. While technical efficiency for manufacturing SMEs as a whole ranges from 84.25 percent to 92.55 percent, it is in the range from 70 percent to 100 percent (full technical efficiency) for the sub-sectors across the three surveys. These levels are higher than those found for Vietnamese manufacturing firms in previous studies (Vu Quoc Ngu, 2003; Nguyen Khac Minh et. al., 2007; Tran Thi Bich et. al., 2008; Pham et. al., 2009) and technical efficiency levels for manufacturing firms in other countries (Tybout, 2000). The sub-sector with the highest technical efficiency is the Wood and Furniture sub-sector, which consistently achieved full technical efficiency. The high-tech Electronics and Electrical Equipment sub-sector has the lowest mean technical efficiency. It is easier to reach the production frontier and achieve high technical efficiency in a sub-sector with simple production technology than in a sub-sector which uses high-tech equipment such as the Electrical and Electronics sub-sector.

The results suggest that Vietnamese manufacturing SMEs should upgrade their technology to move the production frontier upward as they have almost exhausted the current production frontier. Better technology and the resulting higher production frontier will enable Vietnamese manufacturing SMEs to move up the value chain and avoid the labour intensive, low skill, and low value-added trap. In addition, Vietnamese SMEs should make better use of their resources so as to increase output from the current level of inputs. The difference in technical efficiency levels across sub-sectors

suggests that specific policies should be developed for each sub-sector. However, better human capital, which can respond to the rapid changes in the economy of Vietnam, is of key importance for a better technical efficiency performance of Vietnamese SMEs. This can be obtained from training provided by government agencies and private sector business development services.

TABLES AND FIGURES

Table 1: Manufacturing SMEs in Operation (2000 – 2007)

	2000	2001	2002	2003	2004	2005	2006	2007
Number of Manufacturing SMEs	9,150	10,982	13,143	15,003	18,434	21,840	24,553	31,057
Share of Manufacturing SMEs in Total Manufacturing Firms	87.99	88.90	88.84	88.69	89.79	90.94	91.40	91.89
Distribution of Manufacturing SMEs by Sub-sectors (%)								
Producing food and beverage	35.54	30.40	27.87	25.27	22.55	21.68	20.73	19.72
Manufacture of tobacco products	0.14	0.15	0.09	0.09	0.08	0.06	0.06	0.05
Textiles	3.43	3.56	3.90	3.90	3.87	4.13	4.45	4.29
Manufacture of wearing apparel dressing and dyeing of fur	4.07	4.84	5.17	5.47	6.11	5.97	6.04	6.27
Tanning, dressing of leather and manufacture of luggage handbags	1.13	1.35	1.38	1.33	1.58	1.67	1.47	1.52
Wood processing, manufacture of products made from bamboo	7.60	7.59	7.70	7.44	7.59	7.52	8.04	8.13
Manufacture of pulp paper and paperboard	3.99	4.20	4.01	4.30	4.23	4.35	4.33	4.11
Publishing, printing and reproduction of recorded media	2.80	3.61	4.19	4.90	5.71	5.81	6.98	6.63
Manufacture of coke, refined petroleum and nuclear fuel	0.12	0.11	0.10	0.07	0.09	0.07	0.12	0.09
Manufacture of chemicals and chemical products	3.85	4.22	4.34	4.63	4.50	4.57	4.72	4.57
Manufacture of rubber and plastic products	4.66	5.23	5.75	5.64	5.90	6.31	6.37	6.62
Manufacture of other non-metallic mineral products	10.74	9.91	8.70	7.98	7.79	7.30	6.88	6.64
Manufacture of metal	1.16	1.42	1.59	1.67	1.65	1.78	1.82	1.96
Manufacture of metal products	6.40	7.56	9.05	10.10	11.18	11.61	12.13	12.91
Manufacture of machine and other equipment	2.31	2.62	2.76	3.02	3.00	2.99	2.92	3.06
Manufacture of office accounting and computing machinery	0.02	0.05	0.08	0.09	0.12	0.10	0.10	0.11
Manufacture of engines and other electrical equipment	1.53	1.53	1.61	1.69	1.84	1.72	1.67	1.45
Manufacture of radio, television and communicative equipment	0.79	0.76	0.75	0.79	0.87	0.84	0.78	0.84
Manufacture of medical instrument, accurate instruments, optical instrument and clock	0.42	0.36	0.40	0.35	0.37	0.40	0.45	0.45
Manufacture of motor vehicles and trailers	1.78	1.80	1.86	1.54	1.50	1.54	0.89	1.00
Manufacture of other transport	2.44	2.54	2.37	2.36	2.16	2.17	2.05	2.06
Manufacture of furniture and other products	5.05	6.09	6.22	7.21	7.12	7.25	6.73	7.23
Recycling	0.05	0.12	0.11	0.18	0.20	0.17	0.28	0.31

Note: SMEs cut-off point is 299 employees.
Source: Authors' calculation based on Enterprises Census 2000-2007, GSO.

Table 2: Export-oriented Manufacturing SMEs (2000 – 2004)

	2000	**2003**	**2004**
Number of Export-oriented manufacturing SMEs	1,551	2,225	2,810
Share in Total Manufacturing SMEs (%)	17.3	16.0	17.2

Note: Calculation is for only those years in which export data were collected.
Source: Tran Quoc Trung et al. (2008) as calculated from Enterprises Census 2000 -2005.

Table 3: Summary of Studies about Technical Efficiency of Vietnamese Manufacturing Firms

	Year/Period Examined	Sample Size and Industry	Estimation Technique	Technical Efficiency
Vu Quoc Ngu (2003)	1997-1998	164 manufacturing SOEs in major cities: Hanoi, Hai Phong and Ho Chi Minh City,	Stochastic frontier production function (SFPF)	78.8% (1997) 78.9% (1998)
Nguyen Thang et al. (2005)	1997-2000	207 observations in the textiles and garments sub-sectors	SFPF	81.53% (textiles) 79.02 (garments)
Rand and Tarp (2006:22).	1991-2001	1,128 observations of manufacturing SMEs	SFPF	61%
Nguyen Khac Minh et al. (2007)	2000-2003	1,492 observations of manufacturing SMEs	SFPF and Data Envelopment Analysis (DEA)	49.7% (SFFF) 39.9% (DEA)
Nguyen Khac Minh and Truong Tri Vinh (2007)	2000-2003	1,000 observations of firms in the manufacturing sector	DEA	47.5%
Ha Viet Hoang and Carlin (2007)	2001-2005	4,600 observations of manufacturing firms	DEA	45% - 53% (depending on sub-sectors0
Tran Thi Bich et al. (2008) SMEs	1996 and 2001	608 observations of manufacturing SMEs in the domestic non-state sector,	SFPF	79.6% (1996) 86.7% (2001)
Pham et al. (2009)	2003	10,759 manufacturing firms	SFPF	62%

Source: Author's summary from previous studies

Table 4: Generalised Likelihood Ratio Test for Functional Form

Null Hypothesis: H_0^1: $\beta_4=\beta_5=\beta_6=\beta_7=\beta_8=\beta_9=0$ (Production function is Cobb-Douglas)

		LR Statistics	$\chi^2_{0.95}$ value	Decision
1. Manufacturing	*2002*	141.26	12.59	Reject H_0^1
	2005	2141.06	12.59	Reject H_0^1
	2007	940.95	12.59	Reject H_0^1
2.Food and Beverages	*2002*	53.05	12.59	Reject H_0^1
	2005	849.24	12.59	Reject H_0^1
	2007	235.49	12.59	Reject H_0^1
3. Textile, Garment and Footwear	*2002*	16.79	12.59	Reject H_0^1
	2005	77.26	12.59	Reject H_0^1
	2007	209.57	12.59	Reject H_0^1
4. Electrical and Electronics Equipment	*2002*	38.39	12.59	Reject H_0^1
	2005	34.75	12.59	Reject H_0^1
	2007	32.46	12.59	Reject H_0^1
5. Wood and Furniture	*2002*	12.53	12.59	**Accept H_0^1**
	2005	296.50	12.59	Reject H_0^1
	2007	53.33	12.59	Reject H_0^1
6. Chemical, Rubber and Plastic	*2002*	29.43	12.59	Reject H_0^1
	2005	108.59	12.59	Reject H_0^1
	2007	59.07	12.59	Reject H_0^1
7. Paper, Printing and Publishing	*2002*	23.17	12.59	Reject H_0^1
	2005	54.97	12.59	Reject H_0^1
	2007	23.33	12.59	Reject H_0^1
8. Metal Products	*2002*	26.63	12.59	Reject H_0^1
	2005	315.87	12.59	Reject H_0^1
	2007	107.40	12.59	Reject H_0^1
8. Non-Metallic Products	*2002*	8.05	12.59	**Accept H_0^1**
	2005	157.88	12.59	Reject H_0^1
	2007	36.42	12.59	Reject H_0^1
10. Machinery and Equipment	*2002*	23.78	12.59	Reject H_0^1
	2005	39.99	12.59	Reject H_0^1
	2007	47.93	12.59	Reject H_0^1

Source: Author's calculation.
Note: The test statistics have a $\chi2$ distribution with degrees of freedom equal to the difference between the parameters involved in the null and alternative hypothesis.

Table 5: Observations by Sub-sectors

Sub-Sectors	2002	2005	2007	Sector Total
1.Food and Beverages	114	603	434	**1,151**
2. Textile, Garment and Footwear	79	196	242	**517**
3. Electrical and Electronics Equipment	65	50	79	**194**
4. Wood and Furniture	199	463	378	**1,040**
5. Chemical, Rubber and Plastic	97	162	175	**434**
6. Paper, Printing and Publishing	61	120	124	**305**
7. Metal Products	141	398	408	**947**
8. Non-Metallic Products	84	158	139	**381**
9. Machinery and Equipment	86	78	71	**235**
Manufacturing Total	**943**(*)	**2,228**	**2,050**	**5,204**

Note: (*) Observations from separate sub-sectors do not add up to total manufacturing observations as industries for 17 sampled firms could not be determined.
Source: Author's calculation from survey data.

Table 6: Estimated Frontier Production Function

		Manufacturing						Food and Beverages Processing					
		2002		2005		2007		2002		2005		2007(#)	
		943 firms		2228 firms		2050 firms		114 firms		603 firms		434 firms	
		2002	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
Constant	β_0	3.0133***	0.3873	2.6659***	0.1687	2.6590***	0.2037	5.3479***	1.0614	2.0540***	0.2443	3.352***	0.4111
K (Capital)	β_1	-0.0021	0.0537	-0.0279	0.0224	0.1226***	0.0312	-0.0597	0.1507	-0.0332	0.0444	0.161***	0.0551
L (Labour)	β_2	0.3645***	0.0818	0.3908***	0.0282	0.3864***	0.0408	-0.6690**	0.2811	0.4076***	0.0465	0.302***	0.0823
M (Intermediate input)	β_3	0.3596***	0.0669	0.4039***	0.0290	0.2755***	0.0363	0.9070***	0.1245	0.4910***	0.0498	0.218***	0.0599
K2	β_4	0.0041	0.0033	0.0017	0.0014	0.0060***	0.0023	0.0176*	0.0094	0.0065*	0.0035	0.013***	0.0034
L2	β_5	0.0589***	0.0063	0.0665***	0.0018	0.0589***	0.0034	0.0641***	0.0220	0.0679***	0.0027	0.032***	0.0072
M2	β_6	0.0815***	0.0053	0.0755***	0.0021	0.0837***	0.0026	0.0551***	0.0098	0.0672***	0.0037	0.063***	0.0038
*K*L*	β_7	0.0177**	0.0082	0.0093***	0.0030	0.0097*	0.0050	0.0406*	0.0231	-0.0039	0.0058	-0.002	0.0083
*K*M*	β_8	-0.0218***	0.0065	-0.0071***	0.0028	-0.0267***	0.0043	-0.0627***	0.0125	-0.0041	0.0056	-0.033***	0.0069
*L*M*	β_9	-0.1307***	0.0095	-0.1377***	0.0027	-0.1247***	0.0047	-0.0755***	0.0186	-0.1295***	0.0047	-0.063***	0.0085
Sigma-squared	σ^2	1.3477***	0.0770	0.2567***	0.0163	0.3739***	0.0105	0.7734***	0.2762	0.3825***	0.0457		
Gamma	γ	0.9773***	0.0020	0.9341***	0.0060	0.9438***	0.0036	0.9935***	0.0040	0.9661***	0.0059		
Log likelihood		-125.73		879.89		589.67		20.5723		285.8349			

Note: *, **, *** denote statistical significance at the 0.10, 0.05 and 0.01 level respectively
(#) The likelihood ratio test rejects the presence of technical inefficiency effects
Source: Author's calculation

Table 6: Estimated Frontier Production Function (continued)

		Textiles, Garments and Footwear sub-sector						Electrical and Electronic Equipment Sub-sector					
		2002		2005		2007[#]		2002		2005		2007	
		79 firms		196 firms		242 firms		65 firms		50 firms		79 firms	
		Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
Constant	β_0	1.7327**	1.6333	2.6488***	0.9627	3.6744***	0.8998	1.5982	0.9950	2.0609*	1.1183	2.9398***	1.0753
K (Capital)	β_1	0.0380	0.3856	0.1369	0.0986	-0.1784*	0.1000	0.1783	0.2395	0.0992	0.2070	0.2026	0.1574
L (Labour)	β_2	0.8799**	0.4083	0.2626*	0.1362	0.3578***	0.1248	0.6777**	0.3041	0.4965	0.3611	0.3415	0.2794
M (Intermediate input)	β_3	0.0832	0.3331	0.3716**	0.1720	0.4626***	0.1103	0.1760	0.2746	0.3009	0.2465	0.1648	0.2093
K2	β_4	0.0051	0.0138	-0.0005	0.0063	-0.0008	0.0080	0.0212*	0.0117	0.0218*	0.0132	0.0172	0.0141
L2	β_5	0.0424	0.0317	0.0841***	0.0149	0.0744***	0.0106	0.0139	0.0594	0.0917**	0.0466	0.0978**	0.0438
M2	β_6	0.0678**	0.0221	0.0947***	0.0138	0.0848***	0.0066	0.0963**	0.0344	0.0482***	0.0140	0.1214***	0.0252
*K*L*	β_7	-0.0201	0.0444	0.0138	0.0168	0.0258*	0.0152	0.0205	0.0352	-0.0855***	0.0308	0.0009	0.0365
*K*M*	β_8	0.0019	0.0279	-0.0211	0.0134	-0.0048	0.0113	-0.0719**	0.0343	0.0280	0.0261	-0.0451*	0.0231
*L*M*	β_9	-0.1003**	0.0444	-0.1629***	0.0215	-0.1672***	0.0118	-0.0875	0.0847	-0.1008***	0.0508	-0.1807***	0.0621
Sigma-squared	σ^2	0.4342***	0.1372			0.2236***	0.0275	0.1475**	0.0656	0.0128***	0.0031	0.1485***	0.0329
Gamma	γ	0.8776***	0.0557			0.9044***	0.0189	0.8041***	0.0788	1.0000***	0.0005	0.8386***	0.0312
Log likelihood		-17.0004				55.7643		1.4093		46.0663		15.4251	

Note: *, **, *** denote statistical significance at the 0.10, 0.05 and 0.01 level respectively

[#] The likelihood ratio test rejects the presence of technical inefficiency effects

Source: Author's calculation

Table 6: Estimated Frontier Production Function (continued)

		Chemical, Rubber and Plastics sub-sector						Paper, Printing and Publishing					
		2002		2005		2007(#)		2002		2005		2007	
		97 firms		162 firms		175 firms		61 firms		120 firms		124 firms	
		Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
Constant	β_0	3.1038***	0.9663	1.9780**	0.8919	2.5784***	0.8688	1.5727	1.0457	2.7522***	0.9371	6.1877***	1.0332
K (Capital)	β_1	0.1429	0.1792	0.0819	0.0872	0.2174**	0.1000	0.6575**	0.2916	-0.0427	0.0944	-0.0921	0.2304
L (Labour)	β_2	0.1067	0.5478	0.3101***	0.1151	0.4040***	0.1376	-0.4151	0.4918	0.3381**	0.1462	0.1874	0.2298
M (Intermediate input)	β_3	0.4381	0.4176	0.4779***	0.1131	0.1683	0.1559	0.5624**	0.2448	0.4447***	0.1657	0.1551	0.2301
K2	β_4	0.0083	0.0107	-0.0046	0.0062	-0.0043	0.0057	-0.0136	0.0193	0.0069	0.0068	0.0062	0.0149
L2	β_5	0.1802***	0.0337	0.0667***	0.0077	0.0371***	0.0076	0.0221**	0.0104	0.0822***	0.0124	0.0372	0.0244
M2	β_6	0.1010***	0.0214	0.0643***	0.0087	0.0791***	0.0111	0.0581***	0.0131	0.0726***	0.0145	0.0635***	0.0176
*K*L*	β_7	-0.0635	0.0412	0.0039	0.0102	0.0231	0.0141	0.0532	0.0330	-0.0105	0.0159	0.0145	0.0336
*K*M*	β_8	0.0263	0.0316	0.0008	0.0121	-0.0269**	0.0134	-0.0590***	0.0208	0.0016	0.0104	-0.0171	0.0266
*L*M*	β_9	-0.2384***	0.0508	-0.1270***	0.0114	-0.1018***	0.0163	-0.0510	0.0349	-0.1433***	0.0250	-0.0775**	0.0318
Sigma-squared	σ^2	0.0596***	0.0154	0.0272***	0.0027			0.0277***	0.0088	0.0743***	0.0167	0.1909***	0.0362
Gamma	γ	0.7932***	0.0588	0.3745***	0.0596			0.5279***	0.1327	0.7949***	0.0697	0.8718***	0.0439
Log likelihood		*57.6473*		*88.7263*				*38.4896*		*62.2946*		*22.3350*	

Note: *, **, *** denote statistical significance at the 0.10, 0.05 and 0.01 level respectively

(#) The likelihood ratio test rejects the presence of technical inefficiency effects

Source: Author's calculation

Table 6: Estimated Frontier Production Function (continued)

		Metalware Sub-sector						Non-Metallic Sub-sector					
		2002(#)		2005(#)		2007		2002(+)		2005		2007(#)	
		141 firms		398 firms		408 firms		84 firms		158 firms		139 firms	
		Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
Constant	β_0	1.0898	2.0883	2.8478***	0.4770	2.9335***	0.9407	1.256***	0.252	3.4902***	0.6177	1.7625***	0.7388
K (Capital)	β_1	0.1724	0.2305	-0.2424***	0.0462	0.1724	0.1110	0.048*	0.028	0.0298	0.0778	0.1560	0.1194
L (Labour)	β_2	0.4971	0.4072	0.7138***	0.0909	0.3252*	0.1639	0.210***	0.037	0.4099***	0.1076	0.2846*	0.1514
M (Intermediate input)	β_3	0.3456	0.3069	0.2993***	0.0703	0.2395**	0.1198	0.718***	0.037	0.1981**	0.1002	0.4533***	0.1222
K2	β_4	0.0024	0.0130	-0.0048*	0.0027	0.0043	0.0069			0.0017	0.0057	0.0067	0.0104
L2	β_5	0.1139***	0.0437	0.0734***	0.0075	0.0664***	0.0146			0.0730***	0.0090	0.0614***	0.0180
M2	β_6	0.1008***	0.0218	0.0951***	0.0058	0.0965***	0.0094			0.0917***	0.0068	0.0713***	0.0117
*K*L*	β_7	-0.0220	0.0369	0.0263***	0.0083	0.0202	0.0155			0.0100	0.0123	0.0004	0.0247
*K*M*	β_8	0.0021	0.0305	0.0058	0.0068	-0.0368***	0.0112			-0.0115	0.0099	-0.0227	0.0162
*L*M*	β_9	-0.1990***	0.0588	-0.1886***	0.0100	-0.1411***	0.0189			-0.1523***	0.0125	-0.1138**	0.0252
Sigma-squared	σ^2					0.3162***	0.0408	0.958***	0.204				
Gamma	γ					0.9140***	0.0139	0.967***	0.010				
Log likelihood						68.7615		-11.290					

Note: *, **, *** denote statistical significance at the 0.10, 0.05 and 0.01 level respectively
(#) The likelihood ratio test rejects the presence of technical inefficiency effects
(+) The Cobb-Douglas production function is tested to be the preferred specification.
Source: Author's calculation

Table 6: Estimated Frontier Production Function (continued)

		Machinery and Equipment					
		2002		2005$^{(\#)}$		2007	
		86 firms		78 firms		71 firms	
		Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
Constant	β_0	3.9723***	1.0850	4.8401***	0.9452	-0.1389	0.9080
K (Capital)	β_1	0.2855***	0.1086	-0.1513	0.1067	0.2260	0.1432
L (Labour)	β_2	0.2491	0.1775	0.4238**	0.1981	0.8195***	0.1859
M (Intermediate input)	β_3	0.0455	0.1907	0.1955	0.1527	0.2148	0.1862
K2	β_4	0.0033	0.0075	0.0006	0.0082	0.0177	0.0152
L2	β_5	0.0073	0.0246	0.0213	0.0207	0.0728***	0.0180
M2	β_6	0.0817***	0.0258	0.0604***	0.0116	0.0657***	0.0095
*K*L*	β_7	0.0322	0.0214	0.0302**	0.0177	-0.0559**	0.0255
*K*M*	β_8	-0.0571***	0.0188	-0.0133	0.0171	0.0023	0.0202
*L*M*	β_9	-0.0542	0.0453	-0.0814***	0.0295	-0.1149***	0.0223
Sigma-squared	σ^2	0.1562***	0.0296			0.1767***	0.0472
Gamma	γ	0.9788***	0.0200			0.9592***	0.0248
Log likelihood		*27.1347*				*39.2998*	

Note: *, **, *** denote statistical significance at the 0.10, 0.05 and 0.01 level respectively
$^{(\#)}$ The likelihood ratio test rejects the presence of technical inefficiency effects
Source: Author's calculation

Table 7: Average Technical Efficiency

	2002	**2005**	**2007**	**Average (2002-2007)**
Food and Beverages	80.43%	90.87%	100.00%	90.43%
Textile, Garment and Footwear	81.31%	100.00%	89.17%	90.16%
Electrical and Electronics Equipment	82.74%	69.97%	87.13%	79.95%
Wood and Furniture	100.00%	100.00%	100.00%	100.00%
Chemical, Rubber and Plastic	91.07%	94.01%	100.00%	95.03%
Paper, Printing and Publishing	89.44%	92.38%	88.74%	90.19%
Metal Products	100.00%	100.00%	90.26%	96.75%
Non-Metallic Products	81.57%	100.00%	100.00%	93.86%
Machinery and Equipment	79.71%	100.00%	88.97%	89.56%
All Manufacturing	84.25%	92.55%	92.34%	89.71%

Note: Technical efficiency of 100% shown in the table indicates the absence of technical inefficiency.
Source: Author's calculation

Table 8: Frequency Distribution of Technical Efficiency Level

TE Range (%)	Manufacturing			Food and Beverages			Textiles, Garments and Footwear			Electrical and Electronics		
	2002	2005	2007	2002	2005	2007	2002	2005	2007	2002	2005	2007
	%	%	%	%	%	%	%	%	%	%	%	%
<0.50	3.08	0.31	0.39	6.14	0.66	(--)	7.59	(--)	0.83	4.62	0.00	2.53
0.50 – 0.60	1.48	0.22	0.10	3.51	0.00	(--)	1.27	(--)	0.41	1.54	12.00	1.27
0.60 - 0.70	2.65	0.36	0.15	8.77	0.83	(--)	3.80	(--)	0.41	3.08	48.00	1.27
0.70 - 0.80	5.30	0.85	0.49	13.16	1.49	(--)	6.33	(--)	1.24	7.69	18.00	6.33
0.80 - 0.90	52.28	5.48	8.05	31.58	14.43	(--)	36.71	(--)	28.51	44.62	14.00	27.85
0.90 - 1	35.21	92.77	90.83	36.84	82.59	(--)	44.30	(--)	68.60	38.46	8.00	60.76
Total	100.00	100.00	100.00	100.00	100.00	(--)	100.00	(--)	100.00	100.00	100.00	100.00

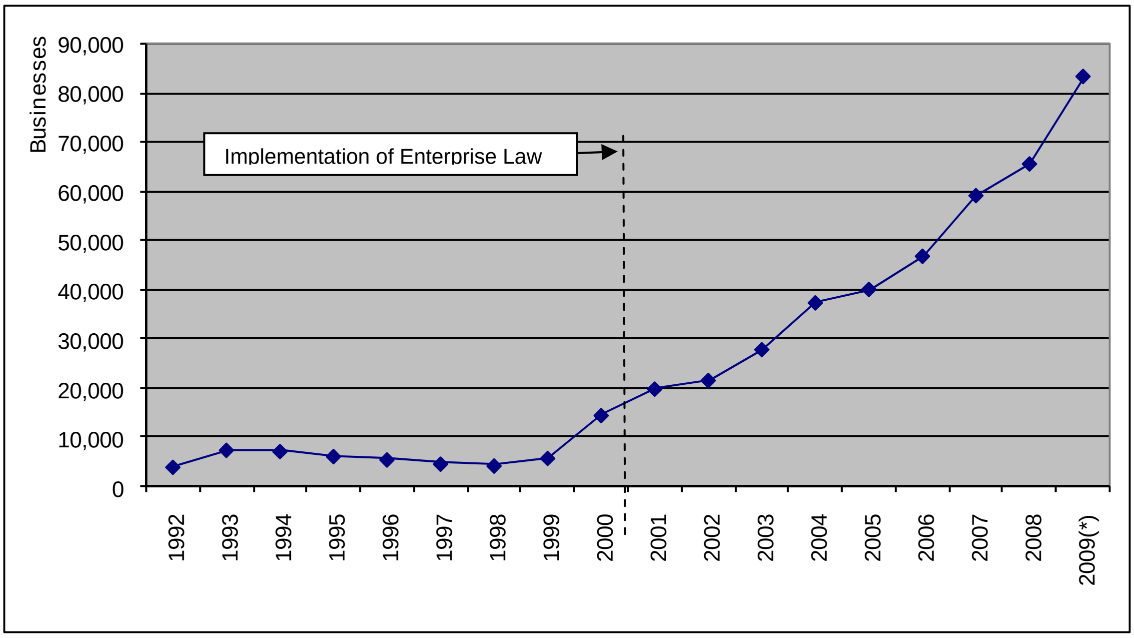
Note: (--) denotes the absence of technical inefficiency
Source: Author's calculation.

Table 8: Frequency Distribution of Technical Efficiency Level (Continued)

TE Range (%)	Chemical, Rubber and Plastics sub-sector			Paper, Printing and Publishing sub-sector			Metalware Sub-sector			Non-Metallic Sub-sector			Machinery and Equipment Subsector		
	2002	2005	2007	2002	2005	2007	2002	2005	2007	2002	2005	2007	2002	2005	2007
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
<0.50	1.03	0.00	(--)	1.64	0.83	0.81	(--)	(--)	0.49	5.95	(--)	(--)	8.14	(--)	1.41
0.50 – 0.60	0.00	0.00	(--)	1.64	0.83	0.00	(--)	(--)	0.00	0.00	(--)	(--)	4.65	(--)	0.00
0.60 - 0.70	2.06	0.62	(--)	6.56	1.67	0.00	(--)	(--)	0.25	2.38	(--)	(--)	9.30	(--)	1.41
0.70 - 0.80	4.12	3.09	(--)	8.20	0.83	4.84	(--)	(--)	0.49	10.71	(--)	(--)	12.79	(--)	4.23
0.80 - 0.90	14.43	8.02	(--)	6.56	9.17	28.23	(--)	(--)	21.57	53.57	(--)	(--)	24.42	(--)	29.58
0.90 - 1	78.35	88.27	(--)	75.41	86.67	66.13	(--)	(--)	77.21	27.38	(--)	(--)	40.70	(--)	63.38
Total	100.00	100.00	(--)	100.00	100.00	100.00	(--)	(--)	100	100.00	(--)	(--)	100.00	(--)	100.00

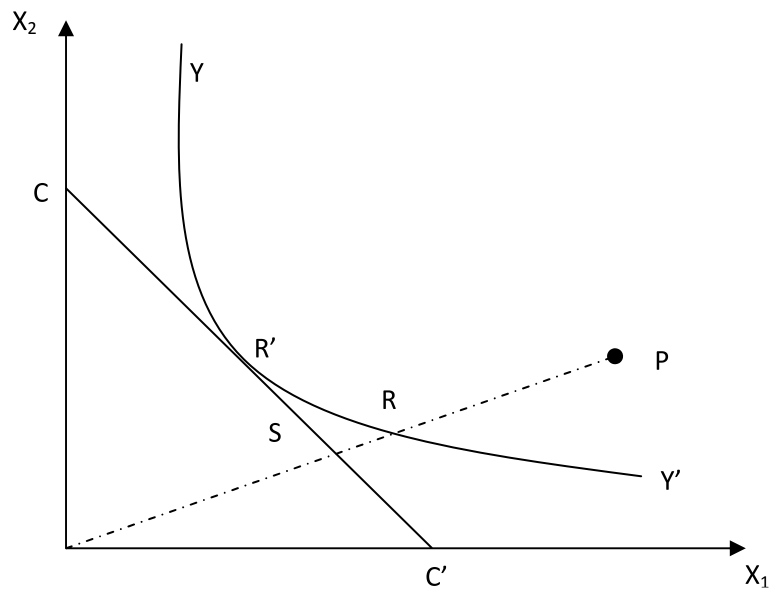
Note: (--) denotes the absence of technical inefficiency.
Source: Author's calculation.

Figure 1: Enterprise Registration Increases Sharply from 2000



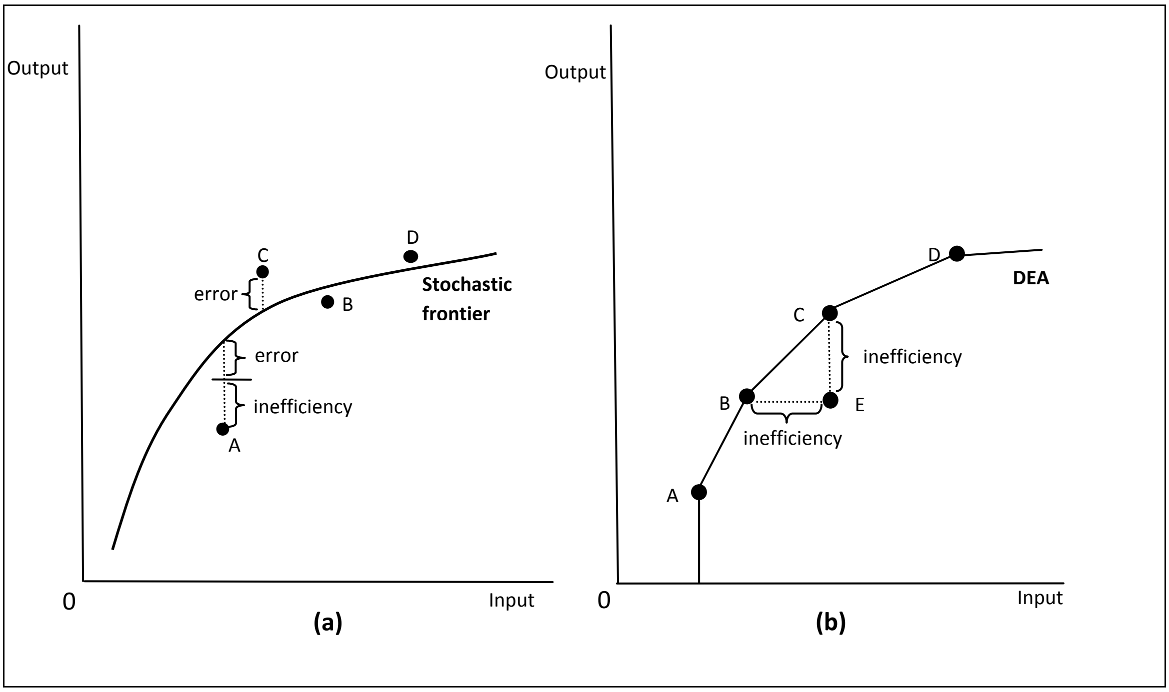
(*) Preliminary data.
Source: National Business Information Centre, Agency for SME Development, MPI, 2009.

Figure 2: Technical and Allocative Efficiency



Source: Murillo-Zamorano (2004).

Figure 3: Stochastic Frontier and DEA Frontier



Source: Adapted from Smith and Street (2005).

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