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Technical Efficiency of The Vietnam's Manufacture of Chemical and Chemical Products: A Dual Approach

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"TECHNICAL EFFICIENCY OF THE VIETNAM'S MANUFACTURE OF CHEMICAL AND CHEMICAL PRODUCTS: A DUAL APPROACH"

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Abstract

This paper is on its way to estimate the technical efficiency (TE) level and identify the sources of technical inefficiency (TIE) of the Vietnam Manufacture of Chemicals and Chemical Products (MCCP) or the chemical industry, using the stochastic frontier cost function and the sample data of 95 MCCP's firms drawn from the Economic Census for Enterprises conducted by the General Statistic Office in 2002.

The empirical results show that the mean TE of the industry is 1.50, implying that the cost of inefficiency of the MCCP is 50 percent above the costs defined by the frontier and also provide that the such firm specific factors as the borrowing to total capital ratio, the service to intermediate cost ratio, ownership and location are the determinants of TIE of the chemical industry.

Based on the TE analysis, some policy implications are proposed for a better performance of TE in the MCCP.

Hanoi, Sep-2004

The manufacture of chemicals and chemical products – MCCP, is an important industry that seems to attract the relatively considerable attention of the State of Vietnam. Despite of certain achievements that contribute to scientific and economic development of Vietnam, according to the Ministry of Industry, the chemical industry is of low competitiveness, backward technology, leading to high production costs, high consumption of raw materials, then high prices and poor quality of products. The TE improvement involves the identification of TE level and determinants of TIE, raising the need for the quantitative study on the industry's efficiency performance. Based on the empirical results, appropriate policies are proposed to minimize the level of the industry's TIE.

1. OVERVIEW OF THE VIETNAM'S MCCP

Major products of the MCCP including fertilizer, pesticide, basic chemicals, electrochemical products, petrochemical products, and other chemical products serve the need for raw materials of other industries and the consumption need. During 1995-2002, the chemical industry has only accounted for an insignificant proportion of the economy, with 6.8 and 5.5 percent of the industrial output value (at constant 1994 prices) of the manufacturing and total industry respectively. In this period, the growth rates have varied over time and were averaged at 16.3 percent (computed from the GSO, 1995-2002). The MCCP's export turnover has covered nearly 1.3 percent of the whole country's amount in 4 recent years, while the export of the industry holds more than 17 percent compare with that of the whole country.[1].

Most of the industry's establishments are of non-state sector. The percentage of state-owned enterprises (SOEs) becomes lower while the foreign invested enterprises (FIEs) are growing. In 2001, among 2,035 establishments of the MCCP, 3.93 percent belong to the state sector, the non-state enterprises (NSEs) and FIEs make up 90.52 and 5.55 percent correspondingly. A large number of these firms gather in 3 main areas: Area 1- Lao Cai, Bac Giang and Phu Tho Province, Area 2 - Hanoi and adjacent provinces, and Area 3 – Hochiminh City and adjacent provinces.

Several mineral resources are sufficient for the MCCP's production for a long time such as antraxit coal, apatit ore, oil and gas, bauxit ore, salt, titanium ore, chromite, limestone,… However, to meet the growing need, it is required to open new exploitation field in replace of exhausted old ones. The prices of some main materials such as coal and natural gas tend to increase, causing difficulties for the production activities.

In 2002, the product composition of the MCCP in terms of industrial output value at constant 1994 prices is as follows: fertilizer (36.39%), pesticide (3.05%), basic inorganic

[1] Data from GSO according to Vietnam Standard Industrial Classification (VSIC)

chemicals (11.11%), rubber related (19.84%), cleaning preparation (10.80%), electrochemicals (8.79%), paints (4.37%), chemical mine (2.46%), other products (3.19%). (Vinachem). The chemical industry just meet the domestic demand for some products, including phosphate, chlord hydrat (HCl), Na_2SiF_6, cleaning preparations, bicycle and motorcycle tyre. The remaining products are imported, especially imported urea supplying 95 percent of the domestic demand (Vinachem).

Except for the manufacture of cleaning and polishing preparations, cosmetic, electrochemical, which are continuously improved and invested, reach equivalent level as of international one, most of chemical production are of low technology, small scale, or just in form of processing and packaging. No measurements for the environment protection have been implemented although most MCCP's establishments pollute the environment. The labor in the MCCP is mainly of skilled level, while the professionally high skilled just holds negligible amount.

2. THEORETICAL FRAMEWORK

The quantitative analysis has been employed in this paper to determine the level of TE and the determinants of TIE of the chemical industry. Researchers often use the stochastic frontier production function, which does not allow the excess of a firm's output over the production frontier[2]. One firm is considered as fully technically efficient when its actual output equal to the output defined by the frontier. And that firm is inefficient when it operates below the frontier. The level of TIE is the distance from the firm's real output and the production frontier. The TE level is therefore the ratio of the firm's actual output to the maximum possible output when the inefficiency effect does not exist.

This study applied the dual approach – cost approach instead of the primal one – production approach to estimate the TE of each firm, the industry and the effects of firm specific factors on TIE[3]. In classical theory, the cost function also provides the same information reflected by the production function in relevant economic aspects. And the cost frontier function is more appropriate in considering the output and input prices as exogenous and input quantities as endogenous factors[4]. The inefficient firm, following the cost approach, operates above the cost frontier derived from the production function. The TIE level is the distance from the actual production cost to the cost frontier and reflect the firm's ability to raise its output from a certain input mix.

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[2] Refer to Farell (1957), Aigner et al. (1977), Greene (1980), Pit &Lee (1981), Battese & Coelli (1988), Battese & Coelli (1995).

[3] Stevenson (1980), Battese & Coelli (1992), Atkinson & Cornwell (1993, 1994).

[4] Firms often have their own production plans

It is noted that the allocative and scale efficiency are outside the scope of this paper. The study bases on the stochastic frontier cost function (SFCF) model proposed by Huge (1980), which is defined as:

$$y_i = f(x_i;\beta).\exp(v_i + u_i)$$

where i = 1,2,…, n refers to the i^th^ firm; y_i – production cost of the i^th^ firm; $f(.)$ – the cost function derived from the production function; x_i – input and output prices; β - estimated parameters; v_i – disturbance term that follows the normal distribution $N(0,\sigma_v^2)$ to reflect the uncontrollable factors of a production process such as luck or weather; u_i – random variable that is non-negative and follows the normal truncated distribution $N(\mu_i,\sigma_u^2)$ to reflect controllable factors of a production process such as employees and managers' efforts. This is also considered as the cost of inefficiency of the i^{th} firm, with μ_i described as[5]:

$$\mu_i = \alpha z_i + w_i$$

where α denotes vector of unknown parameters; z_i – firm specific factors such as firm's size, firm's age, ownership, ….; w_i - error term that follows the normal distribution $N(0,\sigma_w^2)$, such that u_i is non-negative and truncated at $-z_i\delta$. The TE of the i^{th} firm is $TE = \exp(u_i)$ with $1 \le TE \le +\infty$. For convenience, σ_v^2 and σ_u^2 are replaced by $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2 /(\sigma_v^2 + \sigma_u^2)$ with $0 \le \gamma \le 1$ to measure the impact of firm specific factors on the TIE.

The model is estimated by the maximum likelihood method (ML).

3. METHODOLOGY

Model specification

Based on the characteristics of the cost function[6], constant return to scale characteristic and model tests, the SFCF model is defined as :

$$\ln(C_i / w_i) = \alpha_0 + \alpha_1 \ln VA_i + \alpha_2 \ln(r_i / w_i) + \varepsilon_i \quad (1)$$ [7]

where

i=1,…, n: refer to the i^{th} firm;

C_i: total cost of production of firm i^{th} firm, measured in million VND;

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[5] Battese & Coelli (1995)

[6] The characteristics of the cost function involve (1) non-decreasing in factor prices (2) homogeneous of degree 1 in factor prices, (3) concave in factor prices, (4) continuous in factor prices

[7] Two sides of the equation are divided by the price of labor to hold the constant return to scale and the homogeneity of degree 1 in factor prices.

VA_i: value-added that represents firm's output in one year (million VND);

r_i: price of capital of firm i^{th} (million VND), which is not available in the survey and is approximated based on available data[8];

w_i: average per head wage that is computed by the ratio of the total wage bill drawn from the firm's financial statement to the number of employees;

α_i: estimated parameters;

$\varepsilon_i = v_i + u_i$ where $v_i \sim N(0, \sigma_v^2)$ and $u_i \sim N(\mu_i, \sigma_u^2)$. And μ_i is modelled as[9]:

$$\mu_i = \delta_1 BK_i + \delta_2 SI_i + \delta_3 OS_i + \delta_4 ON_i + \delta_5 DN_i + \delta_6 DS_i + w_i \qquad (2)$$

where

BK_i : ratio of borrowing capital to total capital reflecting the firm's capital structure;

SM_i : ratio of services to intermediate costs describing the cost structure;

OS_i : dummy variable taking the value of 1 if the i^{th} firm is a state-owned enterprise and 0 otherwise[10];

ON_i : dummy variable taking the value of 1 if the i^{th} firm is a non state enterprise and 0 otherwise;

DN_i : dummy variable taking the value of 1 if the i^{th} firm is located in the North of Vietnam and 0 otherwise[11];

DS_i : dummy variable taking the value of 1 if the i^{th} firm is located in the South of Vietnam and 0 otherwise;

w_i : random variable that follow the truncated normal distribution $N(0, \sigma_w^2)$, such that u_i is non-negative

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[8] The price of capital is inferred from its approximation based on the economic theory and available data on firm's output, cost of labor and capital.

[9] There are several firm specific factors such as firm's size, firm's age, ownership, location, technology, capital structure, R&D activities, export, …Due to the unavailability of data and the insignificance of other characteristics, the study chooses only capital structure, cost structure, ownership and location as explanatory variables in (2)

[10] There are 3 types of ownership: state-owned enterprise (including enterprises and limited companies with 100% of registered capital owned by the state, and Stock companies with domestic capital, of which the Government shares more than 50% registered capital), non-state enterprise (domestic enterprises with capital owned by economic sectors or the Government equal or less than 50% of registered capital), and foreign-invested enterprises (wholly foreign invested enterprises and joint venture enterprises between Vietnam and foreigner)

[11] There are 3 types of location: the North (including the Red River Delta, North East and North West),the Centre (North Central Coast and Central Highlands), the South (South East and Mekong River Delta)

Data description

For model estimation, the study use the cross-section sample data drawn from the Economic Census for Enterprises conducted by the General Statistic Office in 2002 involving 95 firms in the MCCP. The STATA 8.2 is employed for estimation procedure. Table 1 below summarizes the variables in the model.

Table 1: Summary of the variables

Variable	*Mean*	*SD*	*Min value*	**Max value**
C	22206.61	37733.98	43.00	219922.00
r	17.91	15.31	1.33	70.97
w	0.18	0.06	0.08	0.46
VA	8732.11	15526.37	15.00	82248.00
BK	0.44	0.27	0.00	1.11
SM	0.12	0.11	0.01	0.54
OS	0.17	0.38	0.00	1.00
ON	0.62	0.49	0.00	1.00
DN	0.28	0.45	0.00	1.00
DS	0.59	0.49	0.00	1.00

Source: Author's calculation based on the sample data

The problem of multicollinearity seems to be insignificant here as the zero-order correlation among the variables are low (see Appendix 3). Among 95 firms, the SOEs account for 21.1 percent, while the NSEs and FIEs cover 62.1 percent and 16.8 percent respectively; the North-based, Centre-based and South based enterprises correspondingly hold 28.4, 12.6 and 59 percent.

4. EMPIRICAL RESULTS

Estimation results and hypothesis tests

Some tests of hypotheses have been conducted based on the likelihood ratio tests[12], which is a generalized approach to testing the statistical hypothesis for choosing an appropriate model.

12 The generalized likelihood ratio test is defined by:

$$\lambda = -2\left[ll(H_0) - ll(H_1)\right]$$

Table 2 shows the results of generalized likelihood ratio tests of hypotheses for the frontier (1) and inefficiency model (2). There are three main tests of hypotheses are conducted based on the likelihood ratio tests, including tests for (i) the functional form of the SFCF, (ii) the distribution of the disturbance term, (iii) the existence of the inefficiency effect as well as the firm specific factors. And the results of these hypothesis tests show that the Cobb-Douglas SFCF with the disturbance term following the truncated normal distribution is appropriate in studying the technical efficiency of the MCCP and the inefficiency effects as well as firm specific factors do exist in the frontier and inefficiency model.

Table 2 : Tests of hypotheses

Hypothesis	Model description	ll(H)	λ computed	λ critical	Decision
H_1	Translog (SFCF) Truncated normal	-64.294			
H_0 (α_3=α_4=α_5=0)	Cobb-Douglas (SFCF) Truncated normal	-65.620	2.651	7.81	Accept Ho
H_1	Cobb-Douglas (SFCF) Truncated normal	-65.620			
H_0	Cobb-Douglas (SFCF) Half normal	-68.302	5.364	3.84	Reject Ho
H_0 (γ= δ_0= δ_1=…= δ_6=0)	Cobb-Douglas (OLS) No inefficiency effects	-74.543	17.847	14.07	Reject Ho
H_0 (δ_1=…= δ_6=0)	Cobb-Douglas No firm specific factors	-74.543	17.846	12.59	Reject Ho

Source: Author's calculation based on the empirical results

The estimated parameters obtained from the ML method are provided in Table 3. The explanatory variables have significant effects on dependent variable in the frontier model at 1 percent of significance level. Among 6 firm specific factors, there are 3 statistically significant ones at 1 and 5 percent of significance level. However, the insignificant variables still explain the inefficiency due to the rejection of hypothesis test for no firm specific factors.

where *ll(H_0)* is the log likelihood value of a restricted model, as assigned the null hypothesis and *ll(H1)* is the log likelihood value of the general or unrestricted model, namely the alternative hypothesis. This test statistic approximately follows the chi-square distribution with the degrees of freedom equal to the number of parameters under alternative hypothesis that differs from the null hypothesis. For the acceptance of the null hypothesis, it involves the lower test statistic λ against the critical chi-square value with 5 percent level of significance .

Table 3 : ML estimates of the frontier and inefficiency model

	Estimated coefficient		SD	t-ratio
Model 1				
Constant	2.620	**	0.266	9.870
ln(*r/w*)	0.770	**	0.098	7.880
ln*VA*	0.854	**	0.047	18.170
Model 2				
Constant	0.290		0.305	0.950
BK	0.441	*	0.224	1.970
SM	-2.806	**	0.973	-2.880
OS	-0.175		0.181	-0.970
ON	-0.187		0.163	-1.150
DN	0.209		0.197	1.060
DS	0.452	*	0.191	2.370
$\sigma^2 = \sigma_u^2 + \sigma_v^2$	0.237	**	0.034	
$\gamma = \sigma_u^2 / \sigma^2$	0.004		0.021	
Log-likelihood	-65.620			

Source: Author calculation based on the empirical results

Note: (*) and (**) : the parameter is significant at 5 percent and 1 percent respectively.

Result interpretation

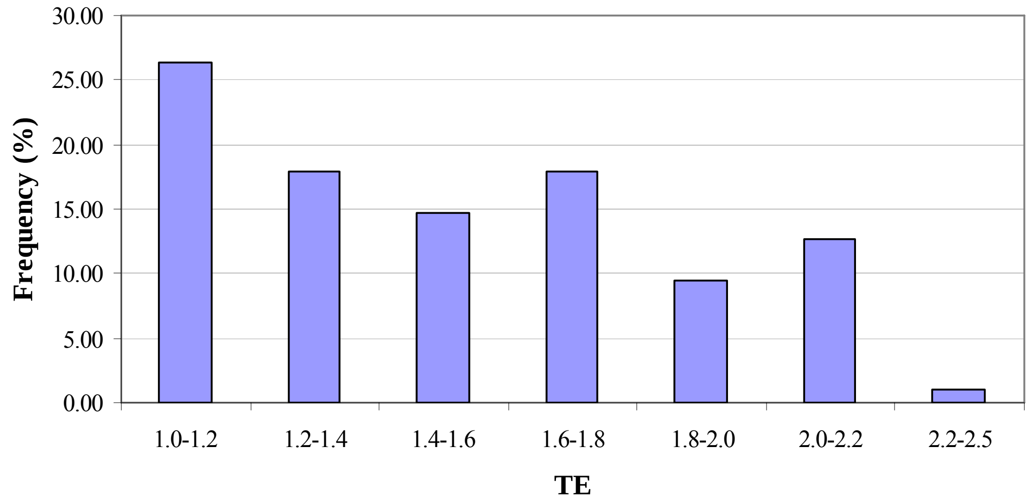
Technical efficiency performance of the MCCP

Each firm's level of technical efficiency are presented in the Appendix 2 and the frequency of different levels of technical efficiency are shown in Figure 1.

The estimated mean TE equals to 1.50 for the MCCP as a whole, implying that the chemical industry spends 1.50 times higher than the most efficiently firm's costs in producing the same output level from the same level of inputs. Or the cost of inefficiency of the MCCP is 50 percent above the cost defined by the frontier.

As clearly seen in Figure 1, the frequency distribution of the chemical industry is unsymmetrical and the frequency tends to decrease associated with the fall in the TE. There exists considerable differences between the individual levels of TE, ranging from 1.0 to 2.47, meaning a variation band of cost increase from 0 to 147 percent above the cost defined by the frontier. A large number of firms have the TE level of 1 to 1.8 (76.84 percent), in which the highest percentage of the sample firms (26.32%) is 1 to 1.2 technically efficient. Other 17.89 and 14.74 percent rank after with the TE of 1.2-1.4, 1.6-1.8 and 1.4-1.6 respectively. Only a small proportion of 23.16 percent possesses the TE level of more than 1.8, proving a profuse room for the decrease of the technical inefficiency.

Figure 1: Distribution of MCCP' technical efficiencies



Source: Author's calculation based on the sample and the empirical results

Determinants of technical inefficiency

In this section, the inefficiency model is employed to analyze the determinants of technical inefficiency. All the estimated coefficients in the model play an important role in identifying and quantifying the impacts of these firm specific factors on the industry's inefficiency, based on which policy implication can be proposed. It is more convenient to rewrite the inefficiency model as:

$$\mu_i = 0,441BK_i - 2,806SM_i - 0,175OS_i - 0,187ON_i + 0,209DN_i + 0,452DS_i \qquad (3)$$

The estimated coefficients are statistically significant from zero at 1 and 5 percent significance level, except for the dummy variables *OS*, *ON* and DN. But we should take these parameters into consideration for the sources of inefficiency as mentioned in the test of hypothesis above. The summary of the sign expectation and meaning of explanatory variables in the model are presented in Table 4.

Table 4: Summary of estimated coefficients and their meanings

Variable	Estimated coefficient	Meaning
BK	0.441	Higher borrowing-capital ratio leads to higher inefficiency level
SM	-2.806	Higher service-intermediate cost ratio cause lower inefficiency level
OS	-0.175	SOEs are more efficient than other types of enterprises a level of 0.175
ON	-0.187	NSEs have lower level of inefficiency than other types of enterprises a level of 0.187
DN	0.209	The North located firm has higher inefficiency than firms in other location a level of 0.209
DS	0.452	The South located firm is less efficient than firms in other location a level of 0.452

Source: Author's derivation from the empirical results

Hereafter is the analysis of the relationship between the technical inefficiency and each firm specific factor.

Borrowing – total capital ratio

The positive estimates of coefficient for the borrowing-capital ratio implies that the more a firm relies on the external source of capital, the higher level of technical inefficiency it will have to face. This is consistent with some previous literature on the role of internal and external source of capital on firm's technical efficiency (see details in the theoretical framework).

To capture the relationship between firm's borrowing-capital ratio and technical inefficiency, the sample are divided into quintiles with 20 percent of sample firms each. Quintile 1 and 5 consists of firms having lowest and highest rate of borrowing to total capital ratio respectively. Table 5 below is the calculation of the mean value of borrowing-capital ratio, service-intermediate cost ratio and the corresponding mean TIE in each quintile and these are illustrated in Figure 2.

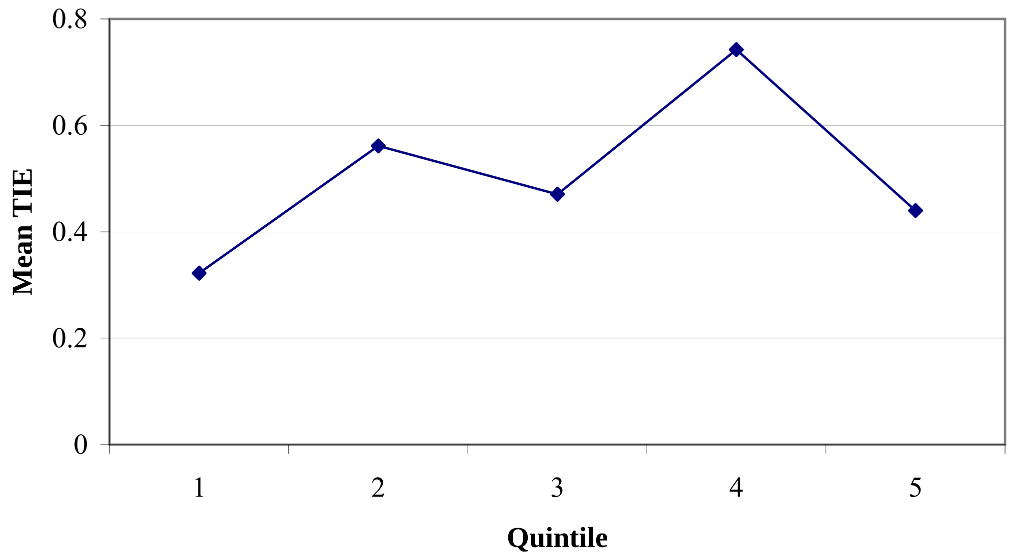
Table 5: Mean value of BK and SM and mean TIE in 5 quintiles

BK quintiles	Mean value of BK	Mean value of SM	Mean TIE
1	0.0785	0.1183	0.32
2	0.2921	0.1100	0.56
3	0.4428	0.1343	0.47
4	0.5678	0.0968	0.74
5	0.8315	0.1618	0.44

Source: Author's calculation based on the sample and empirical results

From Table 5, it can be seen that the most technically efficient firms fall into the first quintile with mean borrowing-capital ratio of about 0.0785, implying that the firms with about 8 percent of total capital amount financed by internal source of capital will have the lowest inefficiency level. However, the mean TIE zigzaggingly increasing over quintiles does not depict the clear trend of technical inefficiency level associated with the borrowing-capital ratio.

Figure 2: Mean technical inefficiency by BK quintiles



Source: Author's calculation based on the sample and empirical results

This can be explained as follows: Certainly small borrowing to total capital ratio results in small amount spent for borrowing and thus the low cost of production then lower level of inefficiency. In addition, high share of equity in total capital encourages the monitoring of investments by the owner, improving the TE. Yet, how high the cost of borrowing might also depends other factors. *Firstly,* the cost of borrowing is dependent on kinds of capital sources, namely formal or informal ones with different interest rates and regulations. The low level of access to official capital resources through banks and financial institution or intermediaries generally leads to the seek for informal financial sources that are much more expensive, thus raise the cost of production. *Secondly*, the manager's pursuit and effort of managers in monitoring the use of the borrowing. Unfortunately these information are not available in the survey.

Service – intermediate costs ratio

The negative estimated coefficient of SM and its high statistical significance describe the opposite direction of service-intermediate cost ratio and inefficiency. The inefficiency level tends to decrease as this ratio rise. Similar to the previous part, the sample is also split into quintiles, with each quintile contains 20 percent of the sample firms and the service-intermediate cost ratio increases over the quintiles. The features and mean TIE in the quintiles are summarized in Table 6 below and graphed in Figure 3.

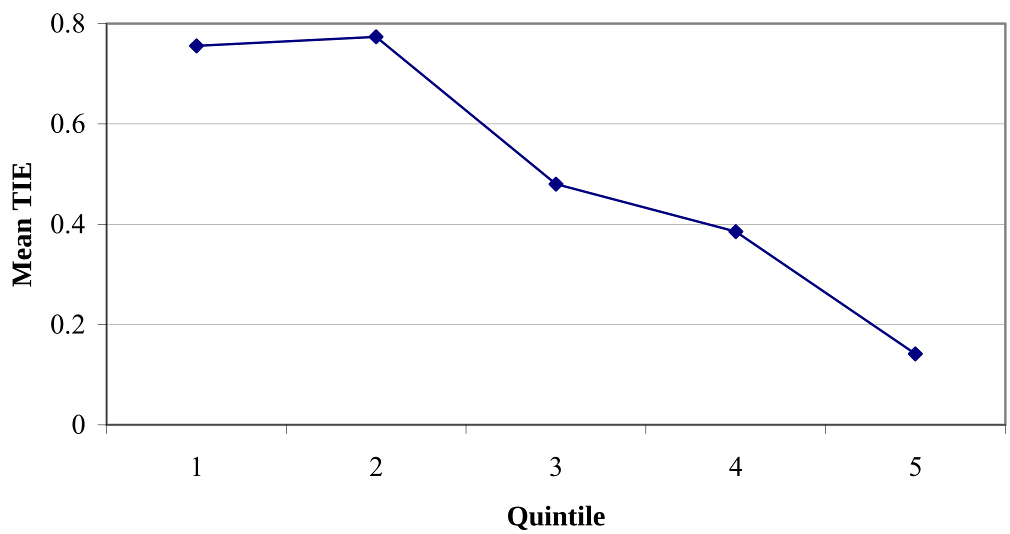
Figure 3 strongly shows positive relationship between the service-intermediate cost ratio and the mean TIE in the quintiles. The lowest mean TIE (0.14) belongs to the 5th SM quintile with the mean SM of 0.29 . In other words, firms spending about 29 percent of intermediate costs on purchase of services are most efficient ones. Then the higher proportion of service cost to intermediate cost, the lower the level of technical inefficiency.

Table 6 : Mean value of BK, SM and mean TE in SM quintiles

BK quintiles	Mean value of BK	Mean value of SM	Mean TIE
1	0.3773	0.0215	0.76
2	0.4302	0.0630	0.77
3	0.4304	0.1015	0.48
4	0.4847	0.1408	0.39
5	0.4902	0.2944	0.14

Source: Author's calculation from the sample and empirical results

Figure 3: Mean technical inefficiency by SM quintiles



Source: Author's calculation from the sample and empirical results

The possible interpretation of this relationship is that the services give support to firm's technical efficiency performance. Various kinds of services such as consultancy services, insurance, supporting services on technology, supporting services on information provide the basis of the sound planning and executing of business and production activities. Firms' managers can take advantage of information on market, price, investment environment, information from the consultants, and so on for making appropriate decisions in monitoring all aspects of manufacture process, from purchase of raw materials, quality controls, distribution net, after-sale service,…

Ownership

As mentioned in the variables description, two dummies OS and ON are used to reflect three main types of enterprises, namely the state-owned enterprises, non-state enterprises and foreign-invested enterprises. According to the estimation results of inefficiency model, both negative coefficients of OS (-0.175) and ON (-0.187) prove that the SOEs and NSEs possess lower level of TIE compared with the FIEs. Table 7 below reflects the main features and mean TIE of types of enterprise.

Table 7: Features and mean TIE of types of enterprises

Types of enterprise	Number of enterprises	Mean BK	Mean SM	Mean TIE
SOEs	16	0.6197	0.1649	0.39
NSEs	59	0.3673	0.1047	0.47
FIEs	20	0.5229	0.1494	0.71

Source: Author's calculation based on the sample and empirical results

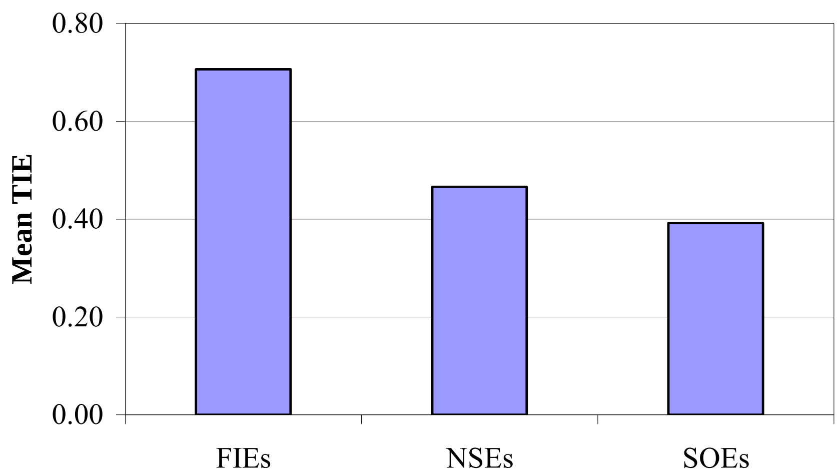
This trend can be seen more clearly in Figure 4 that illustrates Table 7. So the SOEs are the most efficient ones with TIE of 0.39, implying that SOEs' cost of production is on average 1.39 times more than their possible minimum cost. For NSEs and FIEs, the figures for level of inefficiency are 0.47 and 0.71 respectively. Or the SOEs are 18 and 32 percent closer to the cost frontier than the NSEs and FIEs.

Why FIEs rank first in levels of TIE? As in Table 7, FIEs have the second highest mean borrowing-capital ratio and also second highest mean service-intermediate cost ratio. Although expending more than NSEs on service in the structure of intermediate cost, FIEs can not eliminate the negative effect of high share of external capital in total capital on TE. Additionally, the FIEs are often at a disadvantage compared with domestic enterprises which own local knowledge and experiences. We can not exclude the short-term matter in this circumstance. The results might be different in panel data model.

Among 95 sample firms, SOEs are arranged second in the order of mean capital size and value added after FIEs (author's calculation based on the sample), which is consistent to the data of the MCCP. The lead of SOEs in TE level can be attributed to three main reason. Firstly, in the context of open market mechanism and severe competitive environment, SOEs have made effort in improving their efficiency. Secondly, the SOEs gain advantages over

NSEs and FIEs in easier access to capital sources and other favorable State policies (i.e. preferential loans with low interest rate and prolong period, price subsidization, quota). Thirdly, SOEs often attract more well-educated technicians and skilled worker as a result of Vietnamese conception that working in SOEs, though lower paid, will be more stable, prouder than in NSEs and FIEs. These together with the highest rate of service cost in intermediate cost support the SOEs' technical efficiency performance and decreasing the level of inefficiency.

Figure 4 : Mean technical inefficiency by types of ownership



Source: Author's calculation based on the sample and empirical results

Location

The estimated coefficient for two dummies on location DN and DS shown in Table 12 could be interpreted that the North-located and South located firms have the mean inefficiency level of 0.209 and 0.452 higher than Centre-located ones. Or the Centre-located firms are the most technically efficient. This seems not to be as expected but can be accepted by further explanation.

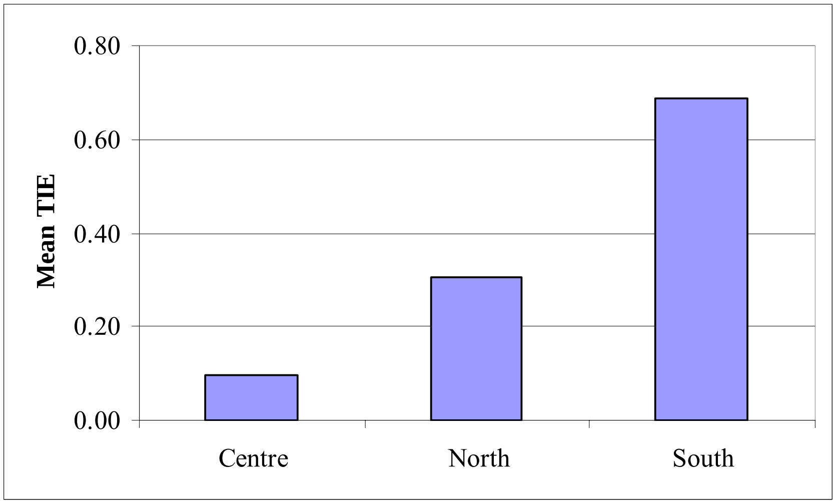
Table 8 : Features and mean TIE by location

Location of enterprise	Number of enterprises	Mean BK	Mean SM	Mean TIE
North	27	0.3971	0.1086	0.31
Centre	12	0.4881	0.2002	0.09
South	56	0.4547	0.1155	0.69

Source: Author's calculation based on the sample and empirical results

As Table 8 and illustrated Figure 5 provide, the Centre-located firms possess the lowest level of TIE (1.09), followed by the North (1.31) and finally the South (1.69). It can be seen clearly that the lowest TIE always comes with highest service-intermediate cost ratio, which is consistent with previous parts.

Figure 5: Mean technical inefficiency by location



Source: Author's calculation based on the sample and empirical results

Besides, the high performance of technical efficiency of Centre-located firms could result from three points as follows: (i) Recent investments focus on the Centre-located enterprises for expanding the existing plants or establishing new ones. The available experiences and the acquirement of new technology and knowledge contribute to the TIE decrease; (ii) the place for processing the raw material and producing near to the exploitation field helps to decrease the transportation cost; (iii) the relative low cost of labor in the Centre also reduces the cost of production.

To understand thoroughly the relationship between the mean technical inefficiency and types of enterprise as well as location, it is necessary to conduct the simultaneous analysis of these two factors, which comes next.

Joint effects of ownership and location

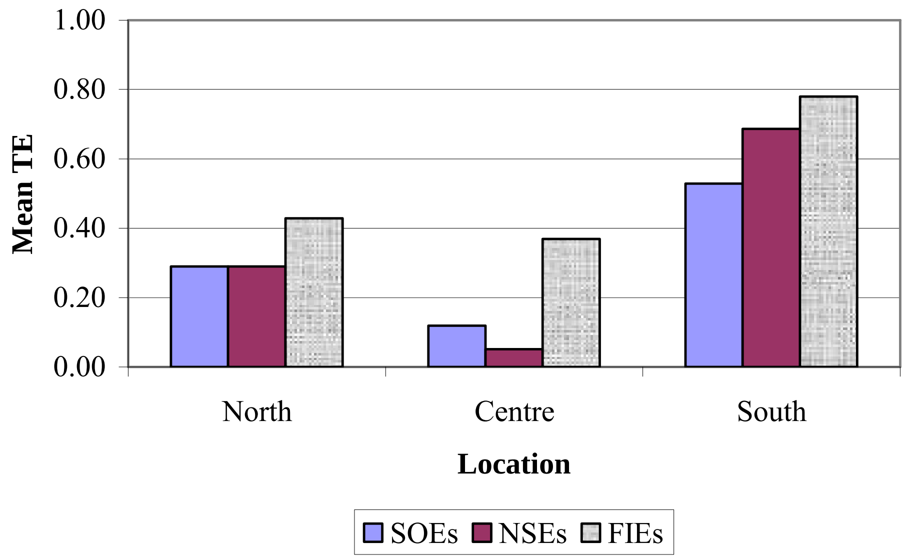
Table 9 presents the computed matrix of the joint effects, in which each component provides the mean TE of a certain type of enterprise and certain location. Figure 6 illustrates Table 9

Table 9 : Joint effects of ownership and location on the mean TIE

	SOEs	**NSEs**	**FIEs**
North	0.29	0.29	0.43
Centre	0.12	0.05	0.37
South	0.53	0.69	0.78

Source: Author's calculation based on the empirical results.

Figure 6: Mean TIE by types and location of enterprise



Source: Author's calculation based on the empirical results.

As observed, the Centre-located NSEs have the lowest level of inefficiency, then the Centre-located SOEs and FIEs ranks two and third. The South-located FIEs are the most inefficient firms, followed by South-located NSEs. These results are not very different from the findings in previous parts. One highlight realized is that in spite of lowest inefficiency level of SOEs, the Central-located firms of NSEs have a lower level of inefficiency than SOEs of all location.

5. POLICY IMPLICATIONS

Besides the further and comprehensive reforms in all aspects, the empirical results depict that it is necessary to implement the following measures to improve the technical inefficiency of the Vietnam's MCCP.

Firstly, the State should *facilitate the access to the capital resources*, especially for NSEs which mostly possess a small size of capital. Easy road to capital resources would provide the capital and form a more equal and competitive environment, helping reduce inefficiency. This involves widespread mobilization of money from various sources, even the foreign ones, through a system of incentives, and more open and favorable policies for NSEs.

Secondly, though the SOEs predominate in efficiency level, we should *eliminate the distortion derived from the preferential treatment of the State for SOEs* to raise the technical efficiency and create the motive for the development of the industry.

Thirdly, because of strongly negative relationship between the share of service cost in intermediate cost and technical inefficiency, the MCCP should take into consideration the *intensification of service cost*. The State should design the policies and the organization to supply these supporting services for enterprises.

Finally, the State should *pay more attention to the geographical distribution of the MCCP enterprises*. The density of MCCP's enterprises nearby the exploitation field of material might decrease the production cost and enhance the level of efficiency.

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APPENDIX 1: ESTIMATION RESULTS

COBB-DOUGLAS SFCF (TRUNCATED NORMAL DISTRIBUTION)

Stoc. frontier normal/truncated-normal model — Number of obs = 95

Wald chi2(2) = 404.48

Log likelihood = -65.619602 — Prob > chi2 = 0.0000

lnc	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
lnc						
lnr	.769969	.0977405	7.88	0.000	.5784012	.9615368
lnva	.8539387	.047	18.17	0.000	.7618204	.946057
_cons	2.620038	.2655342	9.87	0.000	2.0996	3.140475
mu						
bk	.4411299	.2243915	1.97	0.049	.0013307	.8809291
sm	-2.806025	.9730113	-2.88	0.004	-4.713093	-.8989584
os	-.1752366	.181319	-0.97	0.334	-.5306152	.1801421
on	-.1867316	.1628108	-1.15	0.251	-.5058349	.1323717
dn	.2088754	.1974351	1.06	0.290	-.1780903	.5958411
ds	.4519041	.1910051	2.37	0.018	.0775411	.8262672
_cons	.2901305	.3046075	0.95	0.341	-.3068892	.8871502
/lnsigma2	-1.439589	.1424499	-10.11	0.000	-1.718785	-1.160392
/ilgtgamma	-5.458909	4.932631	-1.11	0.268	-15.12669	4.20887
sigma2	.2370252	.0337642			.1792838	.3133633
gamma	.0042401	.0208264			2.70e-07	.9853545
sigma_u2	.001005	.0049429			-.008683	.010693
sigma_v2	.2360202	.0338281			.1697184	.302322

COBB-DOUGLAS SFCF (HALF NORMAL DISTRIBUTION)

Stoc. frontier normal/half-normal model — Number of obs = 95

Wald chi2(2) = 495.99

Log likelihood = -68.302018 — Prob > chi2 = 0.0000

lnc	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
lnc						
lnr	.6970671	.0936877	7.44	0.000	.5134425	.8806917
lnva	.891793	.0467937	19.06	0.000	.8000789	.983507
_cons	2.178868	.279306	7.80	0.000	1.631439	2.726298
lnsig2v						
_cons	-1.584104	.1866115	-8.49	0.000	-1.949856	-1.218352
lnsig2u						
bk	-1.238125	1.673815	-0.74	0.459	-4.518743	2.042493
sm	-19.822	15.667	-1.27	0.206	-50.52876	10.88477
os	-1.08276	1.773505	-0.61	0.542	-4.558765	2.393245
on	-.3388015	.9961696	-0.34	0.734	-2.291258	1.613655
dn	2.26e+09	.	.	.	.	.
ds	2.26e+09	.851646	.	0.000	2.26e+09	2.26e+09
_cons	-2.26e+09	1.543665	.	0.000	-2.26e+09	-2.26e+09
sigma_v	.4529145	.0422595		.3772196	.5437988	

COBB-DOUGLAS SFCF (NO FIRM SPECIFIC FACTORS)

Stoc. frontier normal/truncated-normal model — Number of obs = 95; Wald chi2(2) = 540.78; Prob > chi2 = 0.0000

Log likelihood = -74.543441

lnc	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
lnr	.6726381	.093205	7.22	0.000	.4899596	.8553166
lnva	.8592951	.0481234	17.86	0.000	.7649749	.9536154
_cons	2.53092	.9669843	2.62	0.009	.6356656	4.426174
/mu	-.0408782	5.534618	-0.01	0.994	-10.88853	10.80677
/lnsigma2	-1.266371	.2990803	-4.23	0.000	-1.852557	-.6801844
/ilgtgamma	-5.971445	117.8746	-0.05	0.960	-237.0013	225.0584
sigma2	.2818526	.0842966			.1568355	.5065236
gamma	.0025441	.2991174			1.2e-103	1
sigma_u2	.0007171	.0844927			-.1648856	.1663197
sigma_v2	.2811356	.0436581			.1955673	.3667039

H0: No inefficiency component: z = -0.132 Prob>=z = 0.553

COBB-DOUGLAS (OLS)

Source	SS	df	MS
Model	152.0913	2	76.0456501
Residual	26.7179411	92	.290412403
Total	178.809241	94	1.90222597

Number of obs = 95
F(2, 92) = 261.85
Prob > F = 0.0000
R-squared = 0.8506
Adj R-squared = 0.8473
Root MSE = .5389

lnc	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
lnr	.6726378	.0947126	7.10	0.000	.4845304	.8607451
lnva	.8592945	.0489017	17.57	0.000	.7621715	.9564174
_cons	2.542526	.2238959	11.36	0.000	2.097849	2.987202

TRANSLOG SFCF

Stoc. frontier normal/truncated-normal model — Number of obs = 95; Wald chi2(5) = 441.57; Prob > chi2 = 0.0000

Log likelihood = -64.294364

lnc	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
lnc						
lnr	1.144749	.4216993	2.71	0.007	.3182331	1.971264
lnva	.9853642	.2334199	4.22	0.000	.5278697	1.442859
lnr2	-.0397297	.0995974	-0.40	0.690	-.2349371	.1554777
lnva2	-.0389826	.0294158	-1.33	0.185	-.0966365	.0186712
lnrlnva	-.1012957	.0941169	-1.08	0.282	-.2857614	.08317
_cons	2.958988	.6253391	4.73	0.000	1.733346	4.18463
mu						
bk	.3667253	.2225078	1.65	0.099	-.069382	.8028327
sm	-2.681615	.9906315	-2.71	0.007	-4.623217	-.7400131
os	-.1226263	.1824341	-0.67	0.501	-.4801906	.234938
on	-.1553129	.1662908	-0.93	0.350	-.4812368	.1706111
dn	.186398	.1876024	0.99	0.320	-.181296	.5540921
ds	.4574365	.1854847	2.47	0.014	.0938931	.8209799
_cons	.2573453	.290372	0.89	0.375	-.3117733	.826464

/lnsigma2	-1.487173	.1456247	-10.21	0.000	-1.772592	-1.201754
/ilgtgamma	-5.506169	4.500255	-1.22	0.221	-14.32651	3.31417
sigma2	.2260107	.0329127			.169892	.3006665
gamma	.0040452	.0181308			6.00e-07	.9649117
sigma_u2	.0009143	.0041034			-.0071282	.0089567
sigma_v2	.2250964	.0329291			.1605565	.2896364

APPENDIX 2 : DATA FOR ESTIMATION

Obs	*C*	*r*	*w*	*VA*	*BK*	*SM*	*OS*	*ON*	*DN*	*DS*	*TE*
1	757	0.217003	10.71429	437	0.103073	0.017787	0	1	0	0	1.10
2	3930	0.160971	13.42169	1119	0.627077	0.116687	1	0	0	1	1.68
3	793	0.127686	8.090909	295	0.155343	0.018122	0	1	0	0	1.13
4	725	0.232857	2.833333	160	0.278013	0.318598	0	1	0	0	1.00
5	846	0.200745	8.75	143	0.32197	0.005215	0	1	0	1	1.98
6	468	0.207452	5.454545	289	0.741122	0.105263	0	1	1	0	1.41
7	956	0.205027	18.66667	273	0.175725	0.10604	0	1	0	1	1.40
8	4101	0.108586	10.11707	2725	0.858336	0.203547	1	0	1	0	1.14
9	4664	0.20355	12.66667	2367	0.885088	0.151302	0	1	0	0	1.07
10	73535	0.169813	32.09587	23002	0.759932	0.111985	1	0	0	1	1.80
11	212	0.209436	7.071429	54	0.198119	0.252252	0	1	0	0	1.00
12	95	0.155966	2.6	52	0.086381	0.09375	0	1	1	0	1.09
13	6769	0.166218	11.70423	771	0.510663	0.038217	0	1	1	0	1.54
14	399	0.332668	2.7	94	0.405839	0.205128	0	1	0	0	1.00
15	7962	0.216861	7.056737	1821	0.790346	0.535225	1	0	0	0	1.00
16	1595	0.40301	3.121212	112	0.219638	0.010288	0	1	1	0	1.47
17	281	0.230348	3.428571	84	0	0.148148	0	1	1	0	1.01
18	446	0.187603	3.05	124	0.352994	0.10221	0	1	1	0	1.20
19	288	0.203738	3.461539	77	0.165644	0.158654	0	1	0	1	1.20
20	1896	0.23235	9.433333	469	0.455728	0.502197	0	1	1	0	1.00
21	16189	0.151316	11.39264	3125	0.893116	0.093851	1	0	0	0	1.28
22	3287	0.2068	11.52632	414	0.47878	0.127583	0	1	1	0	1.18
23	5789	0.242878	7.990868	1841	0.581199	0.094498	0	1	0	0	1.10
24	16471	0.165228	15.50685	3239	0.335081	0.1196	0	1	0	1	1.45
25	2788	0.165494	8.058252	2135	0.319218	0.14537	1	0	0	1	1.35
26	11301	0.197789	10.61386	4085	0.234024	0.106372	0	1	0	1	1.43
27	3647	0.104565	18.30303	3069	0.420125	0.162873	0	0	1	0	1.25
28	3565	0.15131	10.33333	854	0.432017	0.053192	0	0	1	0	1.72
29	1725	0.17755	7.583333	637	0.383783	0.096886	0	1	1	0	1.23
30	6762	0.209699	10.39506	1011	0.515673	0.173728	0	1	0	1	1.35
31	17887	0.127817	15.6	8710	0.443587	0.061565	0	0	0	0	1.37
32	609	0.183853	6.26087	487	0.582524	0.353319	0	1	0	1	1.01
33	43	0.299785	1.333333	15	0	0.035714	0	1	1	0	1.23
34	2195	0.219545	14.02667	1291	0.017645	0.465059	0	1	0	0	1.00
35	14475	0.14523	16.29333	2194	0.536321	0.071835	0	0	0	1	2.18
36	68746	0.15776	37.37005	19430	0.543492	0.07792	0	0	0	1	2.15

37	30559	0.140823	23.51485	9324	0.467919	0.104439	0	1	0	1	1.60
38	12000	0.113301	47.83871	1635	0.590611	0.090082	0	0	0	1	2.12
39	4720	0.08376	33.28	3345	0.738273	0.26092	0	0	0	1	1.40
40	6230	0.154852	15.90769	1356	0.428707	0.216262	0	0	0	1	1.39
41	8359	0.205196	8.920635	2349	0.689593	0.045509	0	1	0	1	2.08
42	526	0.26302	6.545455	50	0.028169	0.110656	0	1	0	1	1.30
43	1865	0.261964	9	208	0.635417	0.023309	0	1	1	0	1.70
44	3911	0.176058	16.44444	266	0.210246	0.014718	0	1	0	1	1.84
45	443	0.192938	4.375	126	0.680693	0.028205	0	1	1	0	1.70
46	11247	0.117351	8.888889	3832	0.702559	0.057065	0	1	0	1	2.03
47	5630	0.161669	21.01818	2306	0.421948	0.062744	0	1	0	1	1.76
48	1814	0.145892	18	795	0.282941	0.061484	0	1	0	1	1.66
49	45918	0.130936	36.30345	7871	0.672611	0.036328	0	1	0	1	2.12
50	40446	0.12271	33.05028	12736	0.484281	0.159639	0	0	0	1	1.66
51	94728	0.154688	26.67939	26250	0.843256	0.127345	1	0	1	0	1.41
52	143331	0.135208	59.73658	29869	0.4465	0.032114	0	1	0	1	1.94
53	219922	0.08863	70.96751	82248	0.496093	0.158226	0	0	0	1	1.68
54	6230	0.25466	9.619355	1783	0.300536	0.103878	1	0	1	0	1.18
55	3703	0.148327	10.45	1060	0.560572	0.005105	0	1	0	1	2.20
56	1810	0.208795	7.352941	504	0.736654	0.022434	0	1	1	0	1.77
57	83	0.230719	6	47	0	0.019231	0	1	1	0	1.29
58	163	0.252963	3.25	57	0.004228	0.117647	0	1	1	0	1.02
59	576	0.16818	10	145	0.360492	0.102881	0	1	0	1	1.53
60	175	0.455466	4.666667	77	0.144928	0.023256	0	1	1	0	1.36
61	1947	0.148358	3.875	440	0.039748	0.015024	0	1	0	1	1.70
62	800	0.143308	44.625	499	0	0.240332	0	0	0	1	1.07
63	4228	0.214126	14.24	783	0.607685	0.096286	0	1	0	1	1.74
64	3810	0.217993	9.85567	1217	0.441764	0.058136	0	1	1	0	1.41
65	2158	0.195915	18.86957	687	0.545097	0.086719	0	1	0	1	1.73
66	4097	0.251341	14.07692	882	0.407125	0.073474	0	1	0	1	1.70
67	20310	0.208596	11.7423	4196	0.543303	0.073737	0	1	0	1	1.80
68	14530	0.193214	19.25961	5785	0.877121	0.12544	1	0	1	0	1.43
69	76305	0.165961	25.65974	19022	0.483738	0.038851	1	0	0	1	1.96
70	81179	0.16151	40.02592	18797	0.337895	0.061956	1	0	0	1	1.72
71	118670	0.105319	65.52697	57704	1.112913	0.522379	0	0	0	1	1.00
72	53297	0.121408	38.57143	28898	0.711061	0.192578	0	0	1	0	1.31
73	45266	0.134866	19.32488	28793	0.446614	0.2057	1	0	0	1	1.21
74	66417	0.17241	30.83871	40940	0.463625	0.103624	0	1	0	1	1.60

75	67658	0.090852	61.25926	42259	0.524311	0.119724	0	0	0	1	1.89
76	49018	0.115123	54.29056	37500	0.206627	0.015672	0	1	0	1	1.82
77	46894	0.182301	19.90516	54211	0.344507	0.328969	1	0	0	1	1.00
78	101166	0.137031	32.27701	45722	0.323785	0.088577	0	0	0	1	1.89
79	223	0.272777	6	107	0.279121	0.163399	0	1	1	0	1.02
80	426	0.268989	8	90	0.194581	0.24507	0	1	0	1	1.01
81	2039	0.130773	9.833333	450	0.405003	0.1283	1	0	0	1	1.47
82	2709	0.202531	18.85714	806	0.175781	0.080229	0	1	0	1	1.50
83	9169	0.200372	17.04878	2321	0.956123	0.026121	0	1	0	1	2.47
84	9873	0.17624	12.52222	1498	0.303219	0.041155	0	1	0	1	1.78
85	113676	0.157925	42.45966	25658	0.581056	0.156425	0	1	0	1	1.46
86	91571	0.096933	45.64312	33621	0.961864	0.165638	0	0	0	1	2.02
87	44098	0.103693	15.90572	37586	0.75435	0.110415	0	0	0	1	2.14
88	62117	0.090902	17.55245	30280	0.341807	0.047171	0	0	0	1	2.14
89	360	0.352785	2.241379	15	0	0.063604	0	1	1	0	1.15
90	2021	0.155587	11.89474	794	0.567292	0.021918	0	1	0	1	2.10
91	7807	0.225481	9.413654	1770	0.127551	0.182879	0	1	1	0	1.01
92	4577	0.176215	16.53488	3695	1.106431	0.189423	1	0	0	0	1.07
93	5488	0.173258	12.38312	4962	0.521753	0.122272	1	0	0	1	1.57
94	15923	0.095939	33.05	5846	0.07304	0.10722	0	0	0	1	1.61
95	49215	0.107193	27.48691	16472	0.54071	0.08053	0	0	0	1	2.13

APPENDIX 3: CORRELATION MATRIX OF VARIABLES

Variable	**lnC**	**lnR**	**lnVA**	**L**	**SM**	**DN**	**DS**
lnC	1.0000						
lnR	-0.5908	1.0000					
lnVA	0.8767	-0.8473	1.0000				
L	0.6115	-0.3692	0.6340	1.0000			
SM	0.0089	-0.0599	0.1039	0.1726	1.0000		
DN	-0.2999	0.4568	-0.3953	-0.1815	-0.0908	1.0000	
DS	0.3358	-0.5470	0.4340	0.2309	-0.0962	-0.7551	1.0000

Source: Author's calculation from the sample