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Vietnamese Enterprise: Application of Stochastic Frontier Production Function

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Abstract: *With an application of the stochastic frontier production function based on cross sectional panel data, the findings show evidence of technical progress, it plays a significant role of firm performance. In addition, although returns to scale (RTS) of enterprises during 2000-2010 is the increasing RTS, this achievement is different in regions placed in Vietnam, which the Central Highlands, the Southeastern, and the Mekong River Delta are the scale of economics. It means that an increase in the scale of production gives a rise in certain benefits to the producers. While the Red River Delta, Northern Midland and Mountain, North Central and Central Coastal Areas are not the scale of production,this shows a limit to the scale of production for these three regions, due to economics of scale are exhausted and diseconomies. Moreover, total factor productivity also confirmed that the Mekong River Delta, the Southeastern, and the Central Highlands are good, while others region are opposite. With what found and mentioned above, policies of the government toward enterprises should be clarified, because each region has different conditions of geography and natural resources. Such the Mekong River Delta, mostly products are agricultural, so a policy of the government that once levels on all regions in nationwide is not really appropriate.*
Key words: *Production function, Vietnamese enterprises, Total factor productivity*

I. Introduction

As argued by Page (1984), a difference in the size of firm causes changes in the quantity of output. Accordingly, total factor productivity (TFP) is also a case and makes a change in technology. Not only enterprises in Vietnam, but all the world, an enterprise can employ inputs, such labor, material, capital based on its capacity. Although Vietnam has a huge number of labor force, its contribution to technical efficiency for enterprises is still questioned, because of lack of skilled labor and lack of capital toward high technology. With a quick growth of Vietnam's economy, particularly during 2000 to 2008, the financial market had been busier, due to positive changes in economic policies of Vietnam. However, due to the global crisis, many enterprises in the world are negatively affected, in that Vietnam is not excluded. Consequently, a number of enterprises in Vietnam are bankruptcy because the financial market and real estate bubble-breaking led to the collapse of a series of business(Nha & Quan, 2014). In addition, reasons of small production scales of Vietnamese enterprises, poorness to mobilize and save capital, weak management skills low qualified workers, limited technology application are included, which make a low contribution to competition and not meet the demands of export markets.

Although there are many papers with arguments on Vietnamese enterprises, the analysis of technical progress, returns to scale (RTS) and TFP of enterprises among regions of Vietnam has not been done yet. This is a reason as a chance for this paper to take part and going to examine impacts of input factors, e.g. working capital, fixed asset and long investment, and total employment on sales output value of firm. However, due to the limited data by General Statistics Office (GSO), detailed information of those input factors are not described in the paper.

II. Enterprise and its contribution

Achievements of local enterprises are a positively representative signal to the country's economy, because the local enterprise is a major source to generate employments, income enhancement, and the national budget growth. Shifting from the rigidities of a centrally- planned economy to market-oriented economy, Vietnamese enterprises are promoted and have more chances to address market needs for both local and foreign markets. In terms of opened door policies, the market entrance of Vietnamese enterprises is stimulated. Consequently, the labor market demand is increased, which the vast number of labor accounting for 85% of total corporate workforce are employed in local enterprises (GSO). In addition, annually, Vietnamese enterprises recruit around half of million labors, use 51% of social labor force, and contribute to more than 40% to GDP.

There is an increase in amount of enterprises for recent years, in which the service sector accounts for the highest share of 67,8% in total, next as the sector of construction and industry occupies 21.8%. Ho Chi Minh City and Ha Noi capital account for the highest share of the total enterprises, due to two main business centers of nationwide. Although the Mekong River Delta (MRD) is famous and popular for agricultural sector, because of advantages of natural resources to serve agricultural development, it accounts for a low share of amount.

In general, Vietnamese enterprises are in process to be restructured to response to the global recession. However, still many enterprises are backward technology compared with regional countries, e.g. Thailand, Indonesia, Singapore, so it causes a weak jump toward the competitive market although the government currently pays more attention to local enterprises through the restructuring programs (mainly focused on state owned enterprises), implications as achievements are still questionable. Additionally, programs of improving dynamic finance system, human resource enhancement by advanced trainings, science and technology transfer are taken into account. Unfortunately, thousands of enterprises do not maintain their market place, this is a question that many economists as scientists are paying attention to classify. Therefore, 43.000 enterprises have been broken in 2010, 53.000 enterprises in 2011, 54.000 enterprises in 2012[1]. Innovative programs to enterprises with a low efficiency are extremely considered. However, detailed actions are ambiguous. To contribute into positive development policies to Vietnamese enterprises, this paper is going to find out how input factors impact on firm performance. Its findings is helpful and will be a good reference for policy decision makers to think of appropriate recommendations. However, a large limitation of this paper is data source of GSO, its statistics just provides economic indicators related to capital, labor, and asset and liability of the firm. Information related to others factor are not offered, such as business sector, export situation, market place, etc., so we cannot go further to find out what can affect technical efficiency, for instance, or differences in RTS and TFP by sector.

III. Empirical model

Recently, methodological and empirical work on the economic theory of production function offer suitable framework of examining the enterprise's efficiency, RTS and TFP. Battese & Coelli (1988) used a stochastic frontier production function based on development by Aigner & Lovell (1977). The model in terms of using a time variable to capture the effect of technical progress across countries and regions is paid more attention to. Evidently, Kokkinou (2010) and Tong (1999) employed stochastic frontier function with exponential specification of time-varying effect to measure technical progress.

To estimate technical efficiency and technological progress of the firm, Mastromarco & Ghosh (2009) and Liu & Li (2012) recruited stochastic production frontier function based on arguments of Battese & Coelli (1995). Many arguments on efficient production show that producers can maximize their output level with respect to a given inputs. In terms of finding out effects of inputs on the output growth of firms by panel data, Liu & Li (2012) used stochastic frontier production function, in which independent variables are labor, human capital, and physical capital. In constructing physical capital, they use the real total fixed assets as a proxy variable. The dependent variable of which is defined as the industrial sales output value, measured as the total value of industrial products. Liu & Li found that labor has the largest share in production, but its contribution to the input growth effect is the lowest.

Likely, Arazmuradov et al. (2014) also used stochastic frontier production function to check what the relationship between the output and inputs is. In terms of estimating, real GDP is the dependent variable representing a country's output level. The independent variables of countries' production function are physical capital and total employment employed. Similarly, Seo et al. (2010) also used stochastic frontier production function, with the number of employees as an independent variable, and found out TFP through stochastic frontier analysis with a time varying inefficiency model.

Applying frontier stochastic production function to find out technical efficiency of firms and how relationship between the output and inputs is widespread. Therefore, Charoenrat et al. (2013) used a stochastic frontier analysis on cross-sectional data and find the technical efficiency of the manufacturing small and medium size enterprises of Thai affected by firm size. They suggest that an increase in firm size can cause a good chance for those SMEs access to inputs, such as skilled labor, capital and technology.

With an extent application, three exploratory variables of this paper are recruited and applied in the stochastic frontier production function. The total annual capital of the firm is a proxy of working capital (K), total fixed asset and long term investment are a proxy of physical capital (P)(Liu & Li, 2012), the employees are a proxy of number of labors employed in the enterprise(Arazmuradov et al., 2014; Seo et al., 2010). This model is time-varying technical efficiency, so the time variable is also enclosed in the function as an exploratory variable to capture the effect of technical progress, namely representing technical efficiency of the firm across provinces in the years 2000-2010.

[1] http://songmoi.vn/kinh-te-kinh-doanh/%E2%80%98doanh-nghiep-ngung-hoat-dong-pha-san-da-tro-thanh-dich-roi%E2%80%99

The common production frontier for provinces considered in the study is as below:

$Y_{it} = f(W_{it}, P, L_{it})\tau_{it}\varphi_{it}$ (1)

Where *i= 1, 2,…,N*is asprovinces and *t = 1, 2,…,T*is as variable proxy of time; $Y_{it}$is average sales output value of the enterprise (Liu & Li, 2012) (measured in billion VND) for the *ith* province at time *t. K, P* and *L* are already defined above, in which *K* and *P* are working capital and physical capital respectively, measured by billion VND on average, and *L* is the number of employees measured in average. The efficiency measure is τ_{it}, with $0< \tau_{it} < 1$ and φ_{it} captures the stochastic nature of the frontier.

With adoption through studies of Mastromarco (2008), Seo et al. (2010), and Arazmuradov et al. (2014), the model of stochastic frontier is considered in thies paper as below:

$$LnY_{it} = \beta_0 + \beta_K LnK_{it} + \beta_A LnP_{it} + \beta_L LnL_{it} + \beta_T t + \frac{1}{2}\beta_{KK} LnK_{it} LnK_{it} + \frac{1}{2}\beta_{PP} LnP_{it} LnP_{it} + \frac{1}{2}\beta_{LL} LnL_{it} LnL_{it} + \frac{1}{2}\beta_{TT} t^2 + \beta_{KP} LnK_{it} LnP_{it} + \beta_{KL} LnK_{it} LnL_{it} + \beta_{PL} LnP_{it} LnL_{it} + \beta_{KT} LnK_{it} * t + \beta_{PT} LnP_{it} * t + \beta_{LT} LnL_{it} * t + v_{it} - u_{it} \quad (2)$$

According to the equation (2), if the coefficients of the interaction and squared terms are equal to zero, the model of Cobb-Douglas specification is existed, due to the fact that the equation (2) plays stochastic frontier model of Translog production function. To test the appropriate model specification whether the model (2) is accepted or not, a generalized likelihood ratio test is deployed. The likelihood ratio *LR* test is twice differences in the log-likelihood value for unrestricted and restricted function, and defined as the following.

LR = - 2 (R – U)

Where *R* is restricted log of likelihood of Cobb-Douglas production function, U is unrestricted log of likelihood of Translog production function. The *LR* has approximately λ^2 distribution with degree of freedom equal to the number of parameters assumed to be equal to zero in the null hypothesis. The critical value of *LR* is drawn from Kode & Palm (1986).

With an application of the model (2), returns to scale is derived as below:

$$RTS = \sum \frac{\partial LnY}{\partial LnX_i} \quad (3)$$

Where X_i is input factors(K, P, L)

- RTS > 1: it means the increasing RTS, as an increase in the scale of production give rise to certain benefits to the producers;
- RTS < 1: it means the decreasing RTS, asthere is a limit to the scale of production due to the economies of scale are exhausted and diseconomies;
- RTS = 1: it means the constant RTS, it occurs if a given percentage change in all inputs results in an equal percentage in output.

Based on Battese & Coelli (1995) and Arazmuradov et al.(2014), technical efficiency (TE) scores for enterprises with respect to province *i*at time *t* as follows:

$TE_{it} = exp(-u_{it})$ (4)

Then, a change between period *t* and period *t-1* of technical efficiency (EC) can be expressed as follows:

$EC_{it} = \frac{TE_{it}}{TE_{it-1}}$ (5)

As pointed out by Coelli et al. (2005), technical change (TC) index as the geometric mean between consecutive years of partial derivatives of the production function with respect to time. Once referring to productivity, TFP is taken into account of measuring relevant factors of production. Productivity and efficiency are used popularly and presented a variety of commentators (Coelli et al., 2005).

Therefore,

$$TC_{it} = \sqrt{\left[\left(1 + f_t(Y_{it}, K_{it}, P_{it}, L_{it}, t, \beta_0, \beta) \times \left(1 + f_{t-1}(Y_{it-1}, K_{it-1}, P_{it-1}, L_{it-1}, tT, \beta_0, \beta)\right)\right)\right]} \quad (6)$$

Where f_t is the partial derivative of the translog production function with respect to time *t*, and f_{t-1} is the partial derivative of the translog production function with respect time *t-1*.

TFP is estimated to investigate empirically the role of technology transfer channels in explaining countries' productive performances. As mentioned by Seo et al. (2010), technical efficiency (TE) change and technological change (TC) are identified to address TFP.

$TFP_{it} = EC_{it} \times TC_{it}$ (7)

IV. Data and its description

Data used are cross-sectional panel data with the period 2000-2010 of 63 provinces in Vietnam. Economic indicators in each province are relevant to statistics from firm performance by GSO, in which sales output value on average (Y), annual average capital (W), fixed asset and long term investment (P) are measured in billion VND, while labor is a total number of employees working in the enterprises (L). According to GSO, 63 provinces of Vietnam are grouped into six regions: *(1)* Read River Delta; *(2)* Northern midlands and mountain areas; *(3)* North central and central coastal areas; *(4)* Central highlands; *(5)* Southeastern; *(6)* Mekong River Delta.Provinces belong to Red River Delta (RRD) are Ha Noi, Ha Tay, VinhPhuc, BacNinh, QuangNinh, Hai Duong, Hung Yen, Thai Binh, Nam Dinh, Ninh Binh. Advantages of the RRD are specialization in the sector of industries, services, forest and agriculture. The region's economy contributes 22% to GDP of the country. Recently, the local authority pays more attentions to transitioning from forest and agriculture to industry and construction.

Provinces of Northern midlands and mountain areas include Ha Giang, Cao Bang, BacKan, TuyenQuang, Lao Cai, Yen Bai, Thai Nguyen, Lang Son, BacGiang, PhuTho, Lai Chau, Son La, Hoa Binh. The region of Northern midlands and mountain is a low growth rate, because the condition of natural resource is disadvantageous. Productive system is backward. Although the local authority considers economic transitions, there is still a low implementation process. The main sector of the region is agriculture and forestry.

Provinces belong to North Central and Central Coastal areas are ThanhHoa, NgheAn, Ha Tinh, Quang Binh, Quang Tri, Da Nang, Quang Nam,Quang Ngai. Binh Dinh,Phu Yen, KhanhHoa, NinhThuan, Binh Thuan. Because of the coastal area, the main sector of business is fishery. However, in recent years, services and tourism are more developing. With dynamic policies of the local authority, starting-up business of entrepreneurs is growing up, absorbing a large labor force to join the labor market.

Unlikely others region, Central Highlands are disadvantageous, due to uncomfortable natural condition. Mostly the region's area is highlands, where population is the lowest dense compared to others. A strong point of this region is agricultural production (e.g. cow), long term industry tree (cafe, rubber, etc.), and forestry. Provinces located in Central highlands are Kon Tum, Gia Lai, DakLak,DakNong, Lam Dong.

Provinces of Southeastern are Binh Phuoc, TayNinh, Dinh Duong, Dong Nai, Ba Ria-Vung Tau, and Ho Chi Minh City. The region of Southeastern is a central business of Vietnam with the most crowded population. It is a leading business to increase the balance trade, foreign direct investment and a large contribution to GDP.

The Mekong River Delta (MRD) is the center of agricultural development leading in technology transfer of the whole country. Its share accounts for more than 50% of GDP contribution. Most enterprises located in this region very much consider export driven strategies and have generated employment for local people. Provinces located in the MRD are Long An, Tien Giang, Ben Tre, TraVinh, Vinh Long, Dong Thap, An Giang, KienGiang, Can Tho, HauGiang, SocTrang, Bac Lieu, Ca Mau.

As depicted in Figure 1, 2, 3, 4, 5, 6, there is an increase in the value of economic indicators of enterprises in six regions during 2000-2010. These achievements are derived by contributions of changes in policies of Vietnam's economy in terms of considering more small and medium sized enterprises. With comparison among six regions, Southeastern and RRD are the first leading and the second leading number of enterprises in the period 2000-2010, respectively. This is not so surprised, because each of these two regions has a big city as biggest business centers of nationwide, e.g. Ho Chi Minh City and Ha Noi. For the MRD which is popular for agricultural and fishery production, its number of enterprises is 25,315 in 2010 and 23,220 in 2009, while that of North Central and Central Coastal areas is 40,987 enterprises in 2010 and 36,608 enterprises in 2009, and its number is higher than that of MRD.

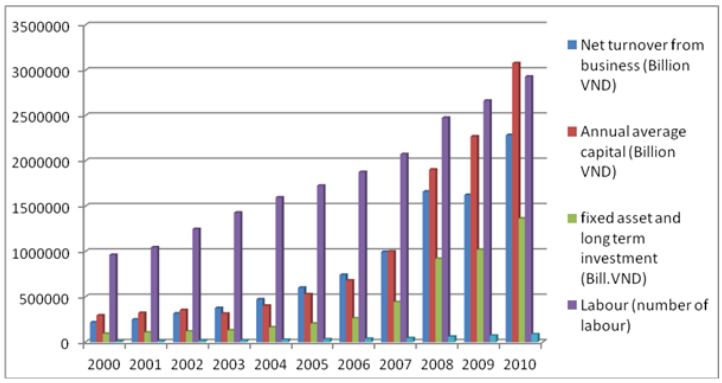

Figure 1: Economic indicators of enterprises in the Red River Delta

Source: GSO

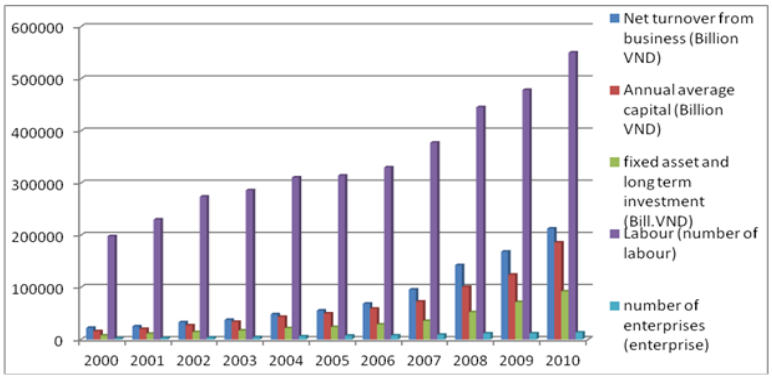

Figure 2: Economic indicators of enterprises in the Northern Midlands and mountain areas

Source: GSO

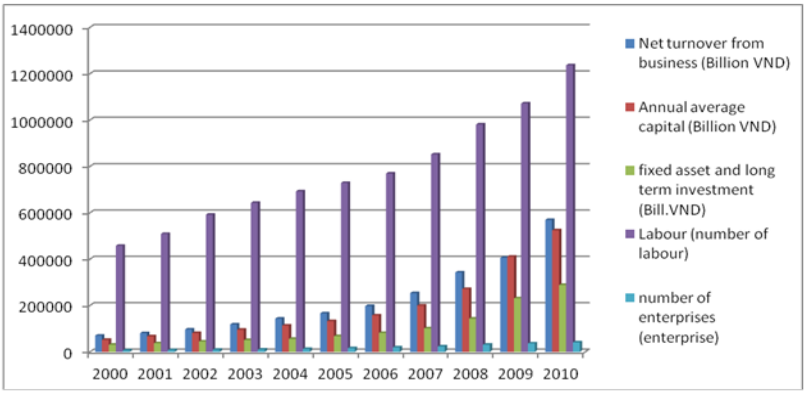

Figure 3: Economic indicators of enterprises in North central and central coastal areas

Source: GSO

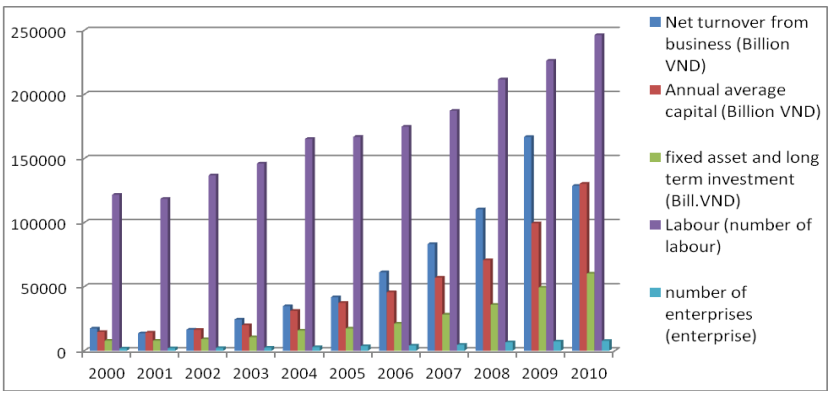

Figure 4: Economic indicators of enterprises in Central Highlands

Source: GSO

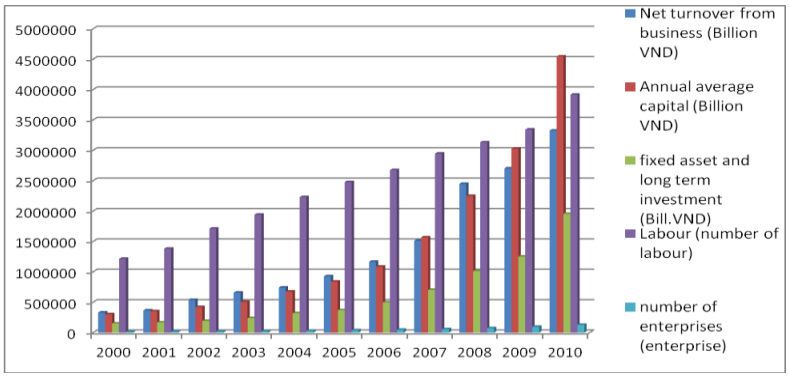

Figure 5: Economic indicators of enterprises in Southeastern

Source: GSO

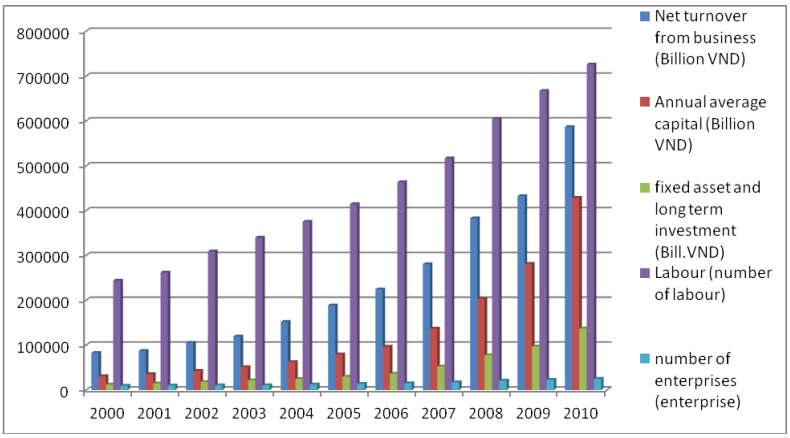

Figure 6: Economic indicators of enterprises in Mekong River Delta

Source: GSO

V. Empirical Results

Estimated results of Translog and Cobb-Douglas models are depicted in table 1. As shown in the last row of table, the log-likehood is 94.195 and 151.399 of the Translog production frontier function and the Cobb-Douglas production frontier, respectively. The likelihood statistics for testing the null hypothesis that the Cobb-Douglas is an adequate of data equal λ = -2(94.195 - 151.399) = 57.204. This value exceeds the critical value (upper 1% with two degrees of freedom) of 8.273 (Kode & Palm, 1986). As a result, the null hypothesis is rejected, meaning that the Translog frontier production function is preferred. Accordingly, technological progress, RTS, and TFP are estimated by stochastic frontier production function of Translog.

At depicted in table 1, the first-order coefficients of inputs, e.g. capital (K), physical capital (P) and labor (L) are significant at all, in which K and L are significant at 5% level, P is significant at 10%. Signs of the coefficient of these three inputs are consistent with the actual situation as the common theory. This means that an increase in the working capital and the labor force of the firm causes a raise in the sales output value of the enterprise. Because the production function in logarithms and variables normalized over their geometric mean(Arazmuradov et al., 2014), a first-order coefficient represents the input elasticity of output. Accordingly, a 1% increase in the working capital leads to 1.15% increase in the enterprises' sales output value. Similarly, the estimated coefficients of the labor is 0.96, this indicates a positive elasticity of labor. However, an increase in physical capital makes a decrease in the output sales value. A 1% increase in physical capital leads to about 0.82% decrease in the Vietnamese enterprise's output sales value. Although this result is not the same to Arazmuradov et al. (2014), this is not really surprised at all because the physical capital is a variable proxy of fixed asset and long term investment. This will be critical for wrong investments of Vietnamese enterprises for last few years. In addition, once the enterprises pay more attention to investing the fixed asset and long term investment, the budget for market activities, such as marketing, research and development can be shrunk. It can cause a decrease in the enterprise's market share at moment. This finding is one of the main reasons to explain why so many Vietnamese enterprises are bankrupt for recent years.

Table 1: Estimate results of stochastic frontier production function

	Translog frontier production		Cobb-Douglas frontier production	
Coefficient	Estimate	P-Value	Estimate	P-Value
Constant	-0.820	0.340	0.866	0.000
LnK	1.148	0.036	0.328	0.000
LnP	-0.823	0.090	0.095	0.025
LnL	0.960	0.031	0.365	0.000
t	0.070	0.203	0.057	0.000
LnKLnK	-0.070	0.296		
LnPLnP	0.172	0.262		
LnLLnL	-0.156	0.210		
t2	0.008	0.002		
LnKLnP	-0.031	0.781		
LnKLnL	-0.002	0.986		
LnPLnL	0.043	0.695		
LnKt	-0.081	0.000		
LnPt	0.074	0.000		
LnLt	0.003	0.850		
/mu	0.934	0.000	1.000	0.000

/lnsigma2	-1.517	0.000	-1.479	0.000
/ilgtgamma	2.034	0.000	1.875	0.000
sigma2	0.219		0.228	
gamma	0.884		0.867	
sigma_u2	0.194		0.198	
sigma_v2	0.025		0.030	
Observation	692		692	
Log-Likelihood	151.399		94.195	

For other variables, such the estimated coefficient for time (t) is not statistically significant, while its second-order effect (t^2) and its interaction with the working capital and labor are statistically significant. As a result, observation shows evidence of technical progress and that such progress played a significant role in the enterprise's performance during the period studied. Accordingly, a positive value of the interaction coefficient is a presentation of positive impact of technical progress on productivity and that of a negative value is a negative impact on productivity. Consequently, there is a significant and negative impact on capacity productivity, and a significant and positive impact on physical productivity. According to Morrison et al. (2000), output elasticity measures include second-order cross terms, e.g., β_{KL} of (2). They are presentation of the impact of a variation in input K on the effect input L on the sales output value. The sign of the second order cross terms β_{KL} provides an estimate of the substitutability or complementary of inputs. As resulted in table, the coefficients of β_{KP}, β_{KL} are negative, there is the complementary between K and P, as well as between K and L. While the coefficient β_{PL} is positive, two inputs of P and L are the substitution. However, unluckily, these coefficients are not significant at all.

Applying the equation (3), RTS are estimated and summarized in Figure 7. In general, RTS of Vietnamese enterprises during 2000-2010 are the increasing RTS, because its value is 1.166 larger than 1. However, enterprises located in regions of the Central Highlands, the Southeastern, the Mekong River Delta are the scale of economics. It means that an increase in the scale of production give rise to certain benefits to the producers. Oppositely, the RRD, Northern Midland and Mountain and North Central and Central Coastal Areas are not the scale of production, because their values of RTS are less than 1. As a result, there is a limit to the scale of production for these three regions, since the economics of scale are exhausted and diseconomies.

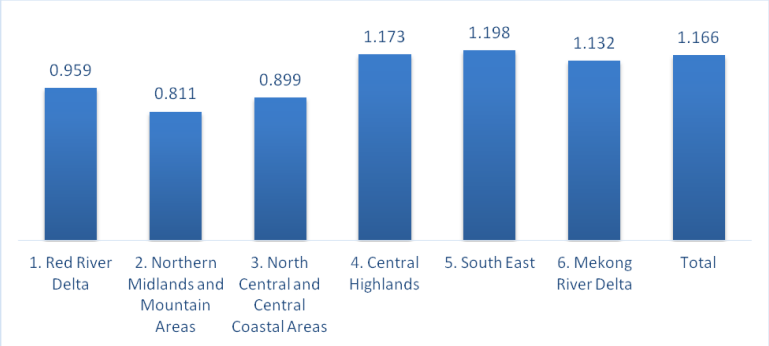

Figure 7: Returns to scale of enterprises by regions

Based on equations of (2), (4) (5), and (6), ~~(7)~~, TFP is estimated. In general, Vietnamese enterprises are good in productivity during 2000-2010 (figure 7), in which the MRD is the highest productivity with 1.682 (as above 100%), next as the Southeastern with 1.352 and the Central Highlands with 1.095. However, the RRD, the Northern Midlands and Mountain Areas and the North Central and Central Coastal Areas can be seen as negative productivity growth, particularly Northern Midlands and Mountain Area with 0.716. As a result, enterprises located in the south of Vietnam, they havemostly positive productivity growth. This can be usually real improvements during their production and right investment for capital and labor and long term.

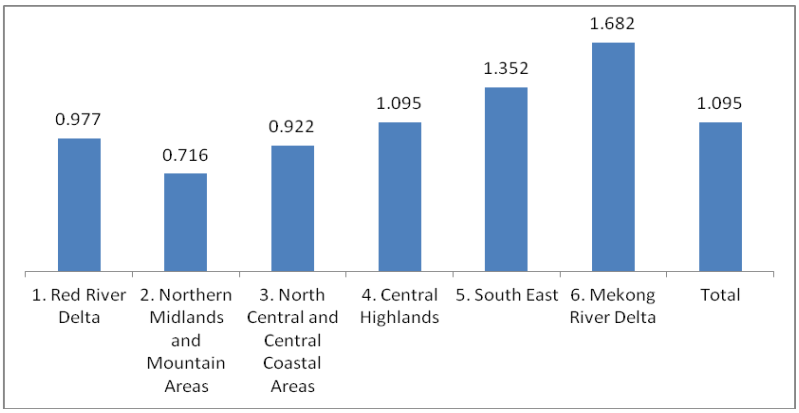

Figure 8: Total factor productivity by region

VI. Conclusion

With application of the stochastic frontier production function based on cross sectional panel data in the period 2000-2010 for 63 provinces in Vietnam, the stochastic frontier production function of Translog is preferred after the test of Kode & Palm (1986) is confirmed.

Supported by the statistical model application on panel data sourced from GSO, the paper finds a positive relationship between the working capital and the enterprise's performance. However, the relationship between physical capital and the output sales value is negative and significant. This finding as a warning for Vietnamese enterprises that they must consider on investing in a fixed asset and long term. Although the finding is different from Arazmuradov et al. (2014) about a negative relationship between the physical capital and the sales output value, this is not surprised completely. Many enterprises must be bankrupted because the real estate market bubble in Vietnam is seriously broken, in which enterprises with business diversification related to asset and long investment bear many damages. In addition, wrong investments of Vietnamese enterprises for last few years should be argued. The finding also presents evidence of technical progress, which plays a significant role to improve the enterprise's performance during the period studied.

Although, in general, RTS of Vietnamese enterprises during 2000-2010 are the increasing RTS, this achievement can be dependent on the region where the enterprise is located. This conclusion cannot be convincing enough, because information related to natural source of the region is not used in the statistical model, but at least this finding is a good reference for policy decision makers to think appropriate policies. The Central Highlands, the Southeastern, the MRD are the scale of economics. It means that an increase in the scale of production gives rise to certain benefits to the producers while the RRD, Northern Midland and Mountain and North Central and Central Coastal Areas are not the scale of production. This shows a limit to the scale of production for these three regions, since the economics of scale are exhausted and diseconomies.

TFP also present that Vietnamese enterprises are generally good in productivity during 2000-2010. Some regions are good, e.g. the MRD, the Southeastern, and the Central Highlands, whereas others are not good, e.g. the RRD, the Northern Midlands and Mountain Areas, the North Central and Central Coastal Areas, which have negative productivity growth. These findings are an important message to central and local policy decision makers to think of necessary changes in future, particularly for the integration economics.

VII. Implication

Based on the above findings, the government and local authorities should think of building capacity of labor forces, particularly that training programs must meet the demand of enterprises. Associations, such as VCCI or local enterprise association, must give more advices to local enterprises of how to use capital effectively, because most of Vietnam enterprises are SMEs, accounting for more than 90%.

Enterprises should be advised to take investment more focusing on main business. Because, as found, the fixed asset and long term investment cause a negative influence on sales output of enterprises. In addition, enterprises are also advised to invest more skilled labor, capital and technology once their RTS is measured. In sum, to avoid risks of the enterprise's investment toward assets and long term investments, the government needs good controls to macroeconomic stability, and considers more capacity building program to improve skilled labors to meet technological development. In additions, market restructure must be concentrated to facilitate local enterprises to stable development.

With what found and mentioned above, policies of the government toward enterprises should be clarified, because each region has different conditions of geography and natural resources. Such the Mekong River Delta, mostly products are agricultural, so a policy of the government that once level on all regions in nationwide is not appropriate.

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