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Technical efficiency of FDI firms in the Vietnamese manufacturing sector

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Abstract: The study examines technical efficiency of Foreign Direct Investment (FDI) firms in the Vietnamese manufacturing sector by applying stochastic production frontier model and making use of cross-sectional data in the period 2009- 2013. The average level of technical efficiency of FDI firms is about 60% and it is higher than that of domestic firms (including private firms and state-owned firms). In addition, the study also analyses correlation between technical efficiency of FDI firms and other factors. It finds that there are positive correlations between FDI technical efficiency and net revenue per labour, firm's age or export activities in 2013. However, the study is unable to find evidence of a relationship between FDI technical efficiency and infrastructure or firm's investment activities.

Keywords*:* FDI, Stochastic production frontier, Technical efficiency, Vietnam.

JEL Classification: C21, L25, O33

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Introduction

One of the most important impacts of FDI is the technological and managerial spill-over effects which are expected to occur thanks to the cooperation between FDI and domestic firms. There are two types of FDI spill-over effects: horizontal and vertical. And it is anticipated that these effects are more likely to happen if the FDI firms operate more efficiently. *First* is horizontal spill-over. In the efficient firms, workers are supposed to be high-skilled and they must improve their ability frequently. Hence, when workers change from FDI firms to domestic ones (labour turnovers), the latter will benefit from these high-skilled employees. Besides, if FDI firms operate efficiently, they put more pressure on domestic firms via competition that forces domestic ones to improve their capability to survive in the market. Additionally, efficient FDI firms will certainly take part in exporting activities and consequently create spill-over effects to recipient countries. *Second* is vertical spill-over. The well-performed foreign firms will demand for decent domestic partners with higher requirements on product quality and time delivery. And subsequently, domestic firms must improve themselves to get into the production chain of FDI firms, where they could learn new production techniques or

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management skills (Ghali & Rezgui 2011). However, FDI spill-over effects are not automatically converted to the benefit of the recipients, but depend on FDI absorptive capacity of domestic firms (Ferragina & Mazzotta, 2014; Girma, 2005; Marcin 2008; Tang & Zhang, 2015; Ghali & Rezgui, 2011). If there is a big gap between FDI firms and domestic firms, spill-over effects are unlikely to occur or it only occurs occasionally. As a result, domestic firms could be dominated by FDI ones via competition.

Generally, literature shows that there are two basic conditions for domestic firms to get benefit from FDI firms: *efficient operation of FDI firms and decent capability of domestic firms*. Both of them are crucial, although, this study only draws attention on the first condition as a basis for further studies on the second condition. Let temporarily ignore the condition of absorptive capacity premising that if FDI firms operate more efficiently, domestic ones will absorb more benefit. In other words, it is assumed that domestic firms are ready to absorb FDI-generated spill-overs, and then the study only focuses on whether FDI firms have operated efficiently or not.

It is becoming more important in the case of Vietnam where the role of FDI is essential. FDI has not only contributed to the economic growth and restructuring but also improved labour productivity, facilitated exporting activities and created new jobs. But there is a concern that FDI firms could have done better. Therefore, this study attempts to examine the efficiency of FDI firms in the Vietnam manufacturing sector from 2009 to 2013. Moreover, a comparison between FDI firms and domestic firms is also conducted by estimating technical efficiency of these firms. Basically, combining inputs and technology to produce output will create a potential production frontier of a specific firm. If real output of the firm is equal to potential output, this firm is technically efficient. If the real output of the firm is not equal to the potential output, then the firm is technically inefficient. However, when estimating production frontier, firms within one industry are assumed to use the same type of technology. The manufacturing sector comprises of many sub-sectors, therefore, it is insignificant to estimate the production frontier for the manufacturing sector as a whole. As a result, the study only chooses 04 sub-sectors which contribute importantly to growth of manufacturing sector. They are: electronic, automobile, textiles and wearing apparel sub-sectors.

Contribution of this paper is to evaluate the efficiency of FDI firms to provide an empirical background for further studies on FDI absorptive capacity in emerging economy of Vietnam. More specifically, the study exploits data of three-digit industry instead of two-digit industry in the previous studies. In addition, if one firm operates in many sub-sectors, only data of observed sub-sectors (electronic, automobile, textiles and wearing apparel) will be used to avoid bias from other sub-sectors. Furthermore, some influential factors of technical efficiency of FDI firms will be analysed to enrich literature about current state of Vietnam economy.

The remainder of the paper is organized as follow. The next part is background and it is followed by the method part to estimate efficiency of FDI firms. Then, the main results will be discussed and the final one is conclusion.

Background

Vietnam is fostering modernization process in order to become an industrial country in 2020. Within this process, contribution of FDI sector is crucial, particularly in the manufacturing sector. FDI inwards into this sector is the largest and until 2013 the accumulated registered capital has reached USD 141406.7 million, accounting for 55.95% of total registered capital into Vietnam (Table 10 in the Appendix).

From 2001 to 2013, proportion of FDI capital in the manufacturing sector has increased remarkably and comprised of 59% in 2013 (Figure 3 in the Appendix). Consequently, the value added of the manufacturing sector created by the FDI sector is also the highest (in 2013, this number is about VND 3000 billion, comparing to about VND 160 billion and VND 600 million of non-state and state sectors respectively). More importantly, the gap between the value added created by the FDI sector and the domestic sector (including the private sector and the state-owned sector) has increased from 2010 (Figure 4 in the Appendix). In addition, the FDI sector also creates more job than the domestic sector. The number of employment of the FDI sector in 2013 is about 2.5 million while these figures of the private and the state ones are 2.3 million and 0.3 million respectively (Vietnam General Statistics Office, 2014).Generally, this information has showed an importance of FDI in the development of Vietnam manufacturing sector. Although the role of the FDI sector is notable, the study attempts to assess whether the FDI sector is performing its best or it could have operated more efficiently.

There are several ways to examine performance of an organization. Worthington & Dollery (2000) indicate that performance of an organization should be assessed by effectiveness and efficiency. Efficiency is "relationship between actual and optimal combination of inputs used to produce a given bundle of outputs" (Worthington & Dollery, 2000, p.27) while effectiveness refers to the level to which an organization reaches its goals or objectives. Effectiveness is measured by outcome-related aspects such as quality, accessibility and appropriateness of outcomes. However, due to lack of data availability, effectiveness of firms is unlikely to be measured, thus the study only focuses on the efficiency of the firms in Vietnam.

The microeconomic theory about efficiency measurement has developed three types of efficiency. *Technical efficiency* refers to the ability to combine inputs (such as labour and capital) in the most technological way to produce certain level of output. *Allocative efficiency* speaks of the capability of the establishment to combine inputs in the optimal way using certain level of inputs' price and technology. In other words, allocative efficiency is to pick up technically efficient choices to produce the largest amount of output. And finally, *productive efficiency* is simply a combination of technical efficiency and allocative efficiency (Worthington, 2001). Because allocative efficiency and productive efficiency are based on the assumption of full technical efficiency of an organization, thus the study only attempts to estimate technical efficiency as a background.

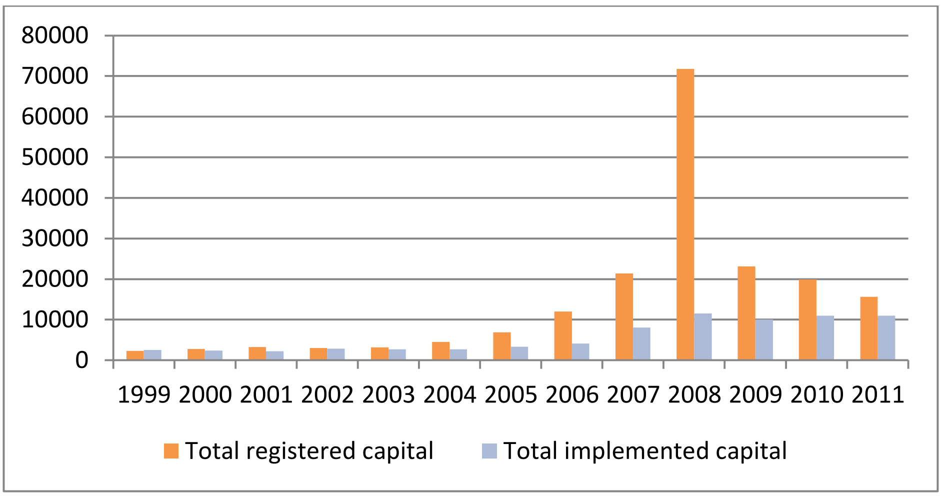
The first author to shed light on the efficiency measurement is Farrell (1957). The author states that the efficiency measurement must be based on the assumption that efficient production function is well-known. However, this function is unlikely to be defined in reality; hence it is necessary to estimate it by applying parametric or non-parametric approach. In fact, there is a substantial part of studies estimating technical efficiency by using parametric, non-parametric approach or both of them. Badunenko, Fritsch, & Stephan (2006) examines determinants of technical efficiency of German manufacturing firms by exploiting a database of Germany cost structure Census from 1992 to 2004 including 35.000 firms within 252 industries. Technical efficiency depends on the location of the firm headquarters, firm's size and R&D intensity. Burki&Dek (1998) study technical efficiency and economy of scale of the Pakistani firms in the 09 manufacturing industries by applying Data Envelop Analysis (DEA – non-parametric approach). The result is that surveyed firms could increase output by 6% to 29% by improving technical efficiency. Lundvall &Battese (2000) exploit a unbalanced panel data to calculate technical efficiency of the Kenyan manufacturing firms by applying stochastic frontier production method (SFP-parametric approach). The authors find that technical efficiency could be affected by the firm's size. In addition, Mahadeven (2000) calculates technical efficiency of the 28 Singapore manufacturing industries from 1975 to 1994 by applying SFP method. The result is that the technical efficiency of the observed firms is 73% in average. Moreover, there are two important determinants of the technical efficiency: the capital intensity and the labour quality. Interestingly, Wu (2000) uses input-oriented distance function approach to calculate the technical efficiency of FDI firms in China between 1983 and 1995 and finds that the FDI performance has inverted J-shape form.

There are also various studies on technical efficiency of Vietnamese firms. Vu (2003) estimates technical efficiency of state-owned firms and non-state firms in Vietnam by using SFP method and exploiting a surveyed data of 164 firms in 1996, 1997, 1998 across Hanoi, Hai Phong and Ho Chi Minh city. The author shows that state-owned firms are more technically efficient than other firms. Besides, the study also figures out determinants of technical efficiency including human capital, location and exports activities. Minh, Long & Thang (2007) calculate technical efficiency of small and medium-sized enterprises in the Vietnamese manufacturing sector by using both DEA and SFP method. The authors exploit a panel data from 2000 to 2003 and indicate some key findings. Technical efficiency of SME estimated by SPF and DEA is 50% and 40% respectively. Tran (2007) studies technical efficiency of Vietnamese pharmacy firms by using cross-sectional data in 2002 and SFP method. Tran concludes that the cost efficiency of these firms is 50% higher than the frontier and the influential factors are debt ratio, ownership and firm's location. Similarly, Le &Harvie (2010) estimate technical efficiency of SME in the Vietnamese manufacturing sector in the period 2000-2007. The authors make use of a panel data of 5,204 SME and apply SFP method to conclude that the technical efficiency of these firms is 89.71% in average. Khai& Yabe (2011) apply SFP method to analyse the technical efficiency of Vietnam agricultural production household in 2005 and 2006. The authors use a panel data of 3,733 households and find that the technical efficiency of these household is 81.6%. Vu (2012) also applies SFP method to estimate technical efficiency of Vietnamese manufacturing firms from 2000 to 2009. He concludes that the private firms are the most efficient ones and they benefit from cooperating with foreigners.

In general, majority of research in Vietnam pay attention on the technical efficiency of the SME or the state-owned enterprises and lack of the research on the technical efficiency of the FDI firms specifically. Therefore, this study will fill the gap by estimating technical efficiency of FDI firms in the manufacturing sector. Moreover, the study also takes a further step by exploiting three-digit sub-sectors including textiles, wearing apparel, electronic and automobile industry to represent for the manufacturing sector. In 2013, value added created by these four sub-sectors ranked the 23rd, 14th, 3rd and 20th over 99 sub-sectors of the manufacturing sectors. In addition, the numbers of the FDI firms and the employment in these sub-sectors are also significant. Moreover, these sub-sectors are identified as the key ones in the Strategy on Industry Development of Vietnam to 2025, vision to 2030 (Decision 879/QD-TTg). Essentially, three sub-sectors are pointed out by World Bank as three of six strategic goods of Vietnam, including electronics parts, apparel and textiles, rice, seafood, footwear and coffee. Hence, it is necessary to conduct a study on these sub-sectors (Blancas et al., 2014).

Importantly, the study focuses on the period 2009-2013 due to the following essential reasons: First of all, Vietnam has joined the World Trade Organization (WTO) in 2007 that could be considered as a remarkable achievement of Vietnamese economy. Vietnam has been one of the most promising destinations for foreign investors. The figure 1 shows evidence that after 2007, inward FDI into Vietnam has increased significantly. It has witnessed an unprecedented registered capital of more than $70 billion in 2008. However, the global financial crisis hampered inward FDI into Vietnam from 2009. Consequently, the period from 2009 to 2013 is vital to examine impact of the WTO accession and global financial crisis on Vietnam economy and particularly, FDI-related issues.

Figure 1 Registered FDI capital and FDI disbursement from 2001-2013 (unit: mil. USD)



Source: Vietnam General Statistics Office

Secondly, the implemented FDI capital from 2009 to 2013 only fluctuated about $10 billion regardless to an increase or decrease of the registered capital. According to Kalotay (2000), absorptive capacity could be understood as a maximum amount of FDI inflow that a recipient could integrate or assimilate into the economy. Then, amount of disbursement could illustratively present for absorptive capacity of Vietnam and it is a tentative signal that the FDI absorptive capacity seems to reach its limitation in this period. Therefore, examining efficiency of the FDI firms could provide a concrete background for further studies on the FDI absorptive capacity.

Thirdly, this period is a pivotal basis for Vietnam to take part in the Transpacific Partnership (TPP) agreement[2] in 2016. FDI-related matters in this period could be essential lessons for Vietnam to prepare for the TPP in which the competition from FDI firms is expected to be fiercer. Obviously, it is better to make up of the most updated data to 2014, however, 2014 data of Vietnam has not yet completed. Then, the study only examines efficiency of FDI firms from 2009 to 2013.

Method

As mentioned above, there are two popular approaches to estimate the technical efficiency of firms: parametric and non-parametric approach. In terms of parametric approach, it is possible to apply deterministic or stochastic frontier production function. The deterministic frontier production function was firstly exploited by Farrell (1957) and Aigner & Chu (1968). This approach could estimate contribution of each production factor and distribution of the error terms. However, some non-technical factors could randomly occur which firms are unable to control. Therefore it is necessary to take the random shock into consideration to establish the stochastic frontier production function (Aigner et al., 1977; Kumbhakar & Lovell, 2003). In terms of the non-parametric approach, the most common method is the Data Envelop Analysis (DEA) but this method is unlikely to examine the effect of random variables on the technical efficiency and consequently could lead to a bias (Zhang et al., 2014).Additionally, DEA uses only small amount of the best efficient firms to indicate the best practical production function. In other words, the approach is very sensitive to the measurement errors (Minh et al., 2007). This is an essential weakness due to the imperfect quality of data in Vietnam. Therefore, the study will make use of the stochastic frontier production function method which to some extends overcomes the disadvantages of the deterministic production function and the DEA approach.

According to Kumbhkar and Lovell (2004) there are n inputs to produce one single output, and then the stochastic frontier production model will be:

$$y_i = f(x_i, \beta).exp\{v_i\}.TE_i \tag{1}$$

Where y_i is output of a firm *i*, x_i is a vector of *n* inputs used by the firm *i*, $f(x_i, \beta).\exp\{v_i\}$is a stochastic frontier production, β is a vector of a technology coefficient, $\exp\{v_i\}$ is random factors that the firm i is unlikely to control and TE_i is the technical efficiency of the firm *i*.

[2] Transpacific partnership is an agreement amongst 12 members about rules for global trade. Further information: https://ustr.gov/trade-agreements/free-trade-agreements/trans-pacific-partnership/tpp-full-text.

From equation (1), the technical efficiency of firm *i* will be:

$$TE_i = \frac{y_i}{f(x_i,\beta).exp\{v_i\}} \tag{2}$$

In which, the technical efficiency is a ratio of the real output that firm i produces to the potential output that the firm i could produce, conditional on stochastic factor $\exp\{v_i\}$. If TE equals to 1, firm i is fully technically efficient and if TE is smaller than 1, firm i is technically inefficient.

Equation (1) could be transformed into:

$$y_i = f(x_i,\beta).exp\{v_i\}.exp\{-u_i\} \tag{3}$$

Where $TE_i = \exp\{-u_i\}$. Technical efficiency is always smaller or equal to 1, thus u_i is always bigger or equal to 0. Assume that $f(x_i,\beta)$ if formed in log-linear Cobb-Douglas function, then the stochastic production function will be:

$$\ln y_i = \beta_0 + \sum_n \beta_n \ln x_{ni} + v_i - u_i \tag{4}$$

v_i and u_i is two components of the error term, in which v_i could be understood as the "noise" component and u_i is a positive component of technical inefficiency. v_i is independent and identical distributed $N(0,\sigma_v^2)$, u_i independent and exponential distributed and v_i and u_i are independent to each other and input variables.

Equation (4) will be estimated by applying maximum likelihood (ML). Thus, maximum likelihood function is presented in standard deviations of frontier function as follow:

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \; and \gamma = \frac{\sigma_u^2}{\sigma^2}$$

σ_v^2 is variance of the "noise" component v and σ_u^2 is variance of the technical inefficiency component. If total error variance σ^2= 0 and u_i = 0 then the firm is fully technically efficient. γ is ratio between variance of the technical efficiency component and the total error variance and has a value from 0 to 1. If γ equals to 0, it means that the bias of production function is created by the "noise" component or uncontrolled factors. In other words, the smaller the value of γ is, the lower the effect of technical inefficiency component is.

It is necessary to test the model. The first one is to test whether the technical inefficiency exists. The null hypothesis is H_0: σ_u^2 = 0 and the alternative hypothesis is H_1: $\sigma_u^2 \neq$ 0. If the technical inefficiency does not exist, the firm is fully technically efficient and the stochastic frontier model will be no longer significant and it is reduced to OLS model. The hypothesis will be tested by one-side generalized likelihood ratio test.

Then, if the technical inefficiency exists, it is necessary to test functional form of the stochastic frontier model. There are two possibilities: Cobb-Douglas function and trans-log Cobb- Douglas function will be presented in the equation (5) and (6) respectively:

$$lnY_i = \beta_0 + \beta_1 lnK_i + \beta_2 lnL_i + v_i - u_i \tag{5}$$

$$lnY_i = \beta_0 + \beta_1 lnK_i + \beta_2 lnL_i + \beta_3 lnL_i^2 + \beta_4 lnK_i^2 + \beta_5 lnL_i * lnK_i + v_i - u_i \tag{6}$$

Assume that there are only two inputs to produce output: capital and labour. Then, Y_i is output of the firm i, K_i is the stock capital of the firm i used to produce output Y and L_i is the number of employment used to produce output Y. The null hypothesis is H_0: $\beta_3 = \beta_4 = \beta_5 = 0$. If the hypothesis is rejected, production function will be trans-log production function; otherwise, it will be Cobb-Douglas production function.

Data

The study exploits cross-sectional data from 2009 to 2013 from Vietnam Annual Enterprises Survey which contains information about type of firms, number of employment, fixed capital, investment, export activities, economic activity, location and net turnover of firms in specific years. The databases are provided by Vietnam General Statistic Office. This study uses these data to estimate the technical efficiency of firms year by year from 2009-2013 in order to allow the comparison between the years. In more details, the database formed by Vietnam Standard Industry Classification (VSIC). There are 21 one-digit industries, 88 two-digit sectors and 242 three-digit sub-sectors. The study only focuses on 4 sub-sectors out of 99 three-digit sub-sectors of manufacturing sectors.

In this survey, one firm could operate in more than one economic activity and these activities could be separated. The study only focuses on 04 sub-sectors of the manufacturing sector: wearing apparel, textiles, automobile and electronic. Therefore, it is necessary to split economic activities of firms into specific ones. For example, if the firm i operates in two economic activities such as: processing and preserving of meat and manufacturing of textiles, the study will split information about textiles, not firm i as a whole.

More specifically, K is capital of firm, proxied by the fixed assets of firms at the beginning of the year. L is the employment of firms at the beginning of the year. Y is the net returns of firms. It will be ideal to proxy Y by the gross output of firm. However, information about output of the specific economic activity of each firm is not available; hence net return of the specific economic activity is used. In addition, the study also filters the database by ignoring firms with negative net returns and non-positive employment and fixed assets. Duplicate firms also are ignored.(Summary of variables is described in the Table 11 and Table 12 in Appendix).

Study uses STATA 14 software to conduct estimating the stochastic frontier production function and the technical efficiency of firms.

Results and discussion

Technical efficiency

The study conducts some robustness tests to improve validity of the model. Firstly, the study tests existence of the technical inefficiency. The results from one-sided generalized likelihood-ratio test[3] show that all of the FDI firms within 04 sub-sectors from 2009 to 2013 are technically inefficient (Table 13 in Appendix). It means that applying the stochastic frontier production function is appropriate. After that, it is necessary to conduct a test on the functional form of the stochastic frontier production function. Results from the tests indicate that majority of the FDI stochastic frontier production functions should be formed as trans-log production functions while results of domestic ones are mixed (Table 14 in Appendix). Additionally, the F-test for joint significance of variables within the models is applied for domestics and FDI firms over year (Table 15 in Appendix). The test results show that the models are robust and reliable. Furthermore, the model specification is tested by link test after regressing. It regress dependent variable on prediction and prediction squared. If the model is correctly specified, then coefficient of prediction squared is not going to be significant. The results from the table 18 of p-value of prediction squared show that the model is correctly specified.

Interestingly, γ value has shown an improvement of FDI firms from 2009 to 2013, particularly in the wearing apparel when γ decreased from 0.7 to 0.41. It indicates that in 2009, 70% of the production function bias was created by the technical inefficiency component and it reduced to only 40% in 2013. In other words, in 2013, 60% of bias of the production function was due to the "noise" component (such as weather condition) that the firm is unlikely to control. Similarly, γ of textiles decreased from 0.53 in 2009 to 0.48 in 2013. FDI firms in automobile and electronic industries have an insignificant improvement, although they have low values of γ (0.33 and 0.44 respectively) (Table 1).

Table 1: γ of FDI firms in 2009 and 2013.

	Textiles	Wearing apparel	Electronic	Automobile
2009	0.5250	0.7046	0.3255	0.4143
2013	0.4824	0.4193	0.3366	0.4020

Source: Author's calculation

The study used functional form test to estimate the stochastic production function of FDI (in comparison with the domestic firms including the state and the private firms) and the technical efficiency of them. Due to word limitation, the table of results of estimated stochastic production function cannot be presented here, but will be provided in request. This paper only shows the table of estimated technical efficiency of the FDI firms and the domestics firms from 2009 to 2013 (Table 2).

[3] Likelihood test is calculated as LR = -2 [log{likelihood(H_0)}-log{likelihood(H_1)}]

Table 2: Technical efficiency of firms 2009-2013

		2009	2010	2011	2012	2013	Average
Textiles	Domestic	0.4911	0.4706	0.5298	0.5058	0.5441	0.5082
	FDI	0.5799	0.5640	0.5798	0.5769	0.6038	0.5809
Wearing.	Domestic	0.5228	0.5162	0.5813	0.5339	0.5685	0.5445
	FDI	0.5167	0.6019	0.5409	0.5734	0.6679	0.5801
Electro.	Domestic	0.4472	0.4471	0.4876	0.5077	0.5083	0.4795
	FDI	0.5645	0.5174	0.5922	0.6568	0.6115	0.5884
Auto	Domestic	0.5802	0.5159	0.5775	0.5458	0.7134	0.5865
	FDI	0.5967	0.5965	0.5964	0.5471	0.6162	0.5906

Source: Author's calculation

Table 2 indicates an improvement in the technical efficiency of majority of the firms in the observed time. Remarkably, the technical efficiency of the FDI firms across the four sub-sectors seems to be higher than this of the domestic firms. It could be explained that the capability to combine inputs and technology of the FDI firms is better than the domestic ones.

In 2013, the technical efficiency of the FDI firms in the observed sub-sectors is somewhat higher than 0.6. The sub-sector with the highest level of the technical efficiency is the wearing apparel (0.667), while the others are approximately 0.6. However, the average levels of the technical efficiency of the FDI firms in the four sub-sectors from 2009 to 2013 are quite similar (Table 2), about 0.59 approximately. This means that the FDI firms in these sub-sectors are only 59% technically efficient. Capability to combine inputs, especially workers, with technology of the FDI firms is 59%. In other words, the FDI firms only operate at about 60% of their full potential capability. On the other hand, this number raises a concern about the level of Vietnam labour force quality. Given this certain level of technology, workers in such FDI firms only make use of 60% of potential in producing goods. Therefore, there is still room to increase the efficiency without changing the technology level by just improving workers' skills.

Apart from 60% of the technical efficiency is the 40% of technical inefficiency (u_i). It is ideal to examine determinants of the technical inefficiency; however, due to lack of available data from Vietnam Annual Enterprises Survey, it is unlikely to finish it. Instead, the study will analyse correlation between the technical efficiency and influential factors

Influential factors of technical efficiency

Firm's size

Firm's size could affect the technical efficiency of a firm. Torii (1992) indicates that maintaining or enhancing the firm efficiency is related to the cost of firm´s administration. That means the decision on investing to maintain or investing to improve the level of output is essential and time/money-consuming. Caves (1992) states that the large firms have lower administration cost than the small and medium ones.

Consequently, cost on maintain or improving output level could be smaller. Hence, it is expected that the larger firms could have better technical efficiency than the smaller ones.

In order to examine this argument, the study only focuses on 2013 data, because it is the most updated data. It is necessary to categorize the FDI firms in 2013 into three groups: large-sized, medium-sized and small-sized firms based on the number of employment and capital.

Table 3: Average technical efficiency by firm's size in 2013

		Textiles		Wearing		Electronic		Auto	
		N	Average TE	N	Average TE	N	Average TE	N	Average TE
Employment	Small	208	0.595	157	0.669	119	0.601	110	0.601
	Medium	39	0.621	51	0.643	30	0.599	20	0.661
	Large	63	0.623	431	0.671	130	0.624	42	0.634
Capital	Small	88	0.522	211	0.648	43	0.568	22	0.572
	Medium	128	0.624	288	0.673	80	0.592	71	0.612
	Large	94	0.653	140	0.689	156	0.634	79	0.633

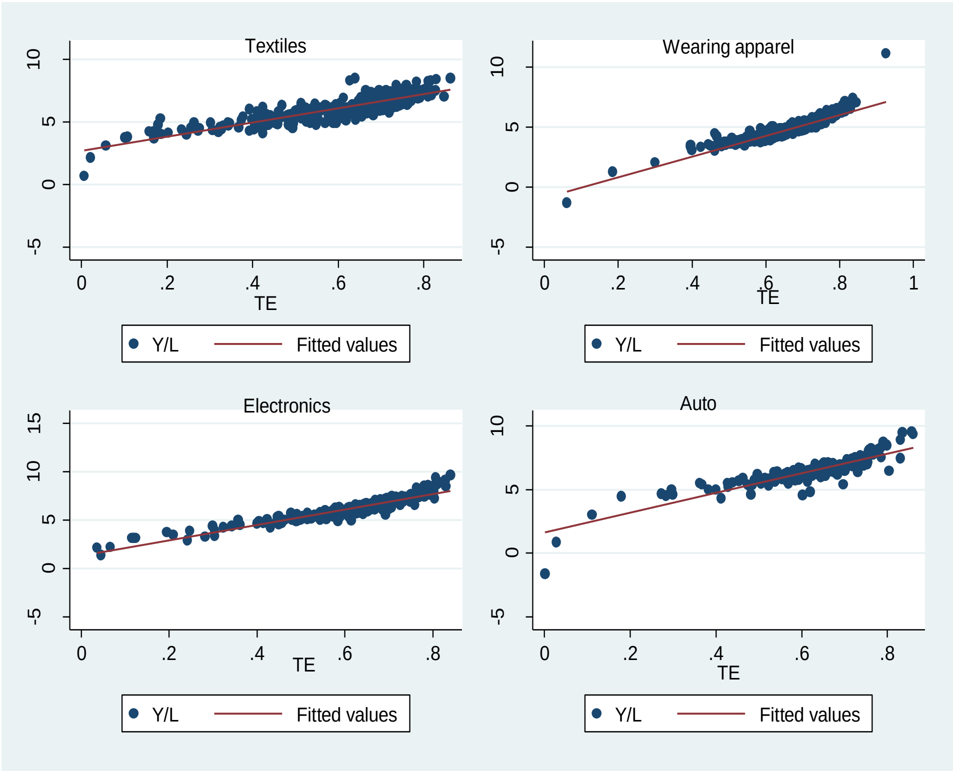
Source: Author's calculation

From the table 3, we can see that, a big proportion of the large FDI firms in 2013 have higher level of the technical efficiency across the four observed sub-sectors. However, the gaps among the large-sized firms and the rest are not really big.

Based on the employment criteria, average technical efficiency of the large-sized firms in the textile sub-sector is 0.623 while those of medium and small-sized ones are 0.621 and 0.595. Similarly, there is no significant gap in the average technical efficiency among firms in the wearing apparel and electronic industries. Even in the auto industry, the average technical efficiency of the medium-sized firms is higher than that of the large-sized ones (0.661 and 0.634 respectively).Turing to FDI firms' technical efficiency based on capital criteria, the difference between the large and the small-sized firms is somewhat clearer. However, the gap between the large and the medium-sized ones is not that significant.

Hence, the study takes a further step by examining the correlation between the FDI technical efficiency and the ratio of capital to employment or the ratio of net returns to employment. The result is that the technical efficiency only significantly correlates to the ratio of net returns to employment (Table 9 in Appendix). Hence, it is possible to state that there is a positive relationship between the technical efficiency and the net returns per worker. Within the observed sub-sectors, textiles and electronics witness the highest level of correlation between the TE and the net returns per employment (0.92 and 0.93 respectively), while these numbers of auto and wearing apparel sub-sectors are about 0.87 (all of these correlations are statistical significant at 1%)(Figure 2).

Figure 2: Correlation between FDI technical efficiency and Y/L in 2013.



Source: Author's calculation

Firm's age

Firm's age is one of important factors of firm efficiency (Lundvall &Battese 2000, Ishita et.al. 2009). FDI firms are anticipated to be more efficient when they operate for a long time in the host countries. Initially, FDI firms could be hampered by strange business culture and environment. However, after getting used to the new environment, the FDI firms could make use of their technological superiority to perform better than the domestic firms.

This argument is confirmed in the case of the four sub-sectors of Vietnam. Correlation between the technical efficiency and the firm's age is positive and statistically significant (Table 4). In which, the correlation of automobile sub-sector is the highest. Although these correlations in textiles and electronics sub-sector are very weak (0.095 and 0.146 respectively), linear relationship is likely to happen due to the good number of observations (310 and 279 respectively).

Table 4: Correlation of FDI technical efficiency and firm's age

Textiles		Wearing.		Electronic		Auto	
N	Correlation	N	Correlation	N	Correlation	N	Correlation
310	0.095*** (0.096)	639	0.212* (0.000)	279	0.146** (0.015)	172	0.220* (0.003)

*Note: * 1% statistically significant; **: 5% statistically significant*
Source: Author's calculation

The study also calculates the technical efficiency of the FDI firms in 2013 across the four sub-sectors based on the firm's age. It is divided into 04 periods: less than five years, 6-10 years, 11-15 years and more than 15 years. The study tests differences in the mean value of the periods by applying one-way analysis-of-variance. The results in Table 16 in Appendix show that the mean values of the technical efficiency of the four groups are statistically different. The table 5 only shows the level of the technical efficiency of the first and the last group to make a comparison. The FDI firms with more than 15 operating years seem to be more technically efficient than the less- than-5-year FDI firms. The most apparent difference could be seen in the automobile industry. The average technical efficiency of the old firms is 0.712 while this number for the young firms is only about 0.6.

Table 5: Average technical efficiency by firm's age

Firm's age	Textiles		Wearing.		Electronics		Auto	
	N	Average TE	N	Average TE	N	Average TE	N	Average TE
>15	22	.6492	56	.6960	17	.6712	19	.7194
<5	105	.5734	227	.6543	157	.5960	73	.6032

Source: Author's calculation

Export activities

The exporting firms must compete fiercely with the international firms; hence they must make use of the production resources in the most effective way. In addition, the international cooperation could help these firms acquire new knowledge, production skills or product designs so that they could improve the firm's efficiency. Studies of Barnard & Jensen (1999), Clerdies, Lach&Tybout (1998) and Aw, Chung &Roberts (2000) agree that the exporting firms are more efficient than the non-exporting firms.

In order to examine this argument in case of Vietnam, the FDI firms are divided into exporting and non-exporting ones. Then, the technical efficiency of the two groups will be calculated to see the contrast.

Table 6: Average technical efficiency by exporting and non-exporting firms

Firms	Textiles		Wearing.		Electronics		Auto	
	N	Average TE	N	Average TE	N	Average TE	N	Average TE
Export.	250	.6349435	541	.6731461	243	.6178338	158	.6263495
Non-export.	60	.4739356	98	.6390356	36	.5690506	14	.5020537

Source: Author's calculation

We can see that the number of the exporting firms is bigger than that of the non-exporting ones across the four sub-sectors. And secondly, the technical efficiency of the former one is notably higher than that of the later one. In the textile industry, the exporting firms are about 63% technically efficient while the non-exporting ones only reach 47% of the technical efficiency in average (Table 6).The differences in the technical efficiency among the exporting and the non-exporting firms are not coincident but statistically significant by t-test (Table 17 in the Appendix). Hence, it is evident that in Vietnam the FDI exporting firms are more efficient than the non-exporting firms in 2013.

Infrastructure

Another influential factor should be domestic infrastructure. Tingum (2014) indicates that electricity, communication and especially road infrastructure have a great impact on operation of the firms in this territory. This argument is also approved by Mitra et al. (2011). It is quite hard to create an index of infrastructure in Vietnam. Therefore, the study will rely on the Provincial Competitiveness Index (PCI)[4] 2013 to proxy for the quality of infrastructure. The result from the PCI shows that the best-infrastructure provinces are Binh Duong, Ba Ria – Vung Tau, Ho Chi Minh an Da Nang. Then, the study calculates an average technical efficiency of the FDI firms within the 04 provinces to examine the argument.

Table 7: Average technical efficiency by provinces

Provinces	Textiles	Wearing.	Electronics	Auto
Binh Duong	0.62	0.68	0.62	0.65
Ba Ria Vung Tau	0.58	0.69	-----	-----
Ho Chi Minh	0.62	0.68	0.60	0.64
Da Nang	0.55	0.68	0.56	0.49
Average TE in 2013	0.60	0.66	0.61	0.61

Source: Author's calculation

[4] More details of PCI index: http://eng.pcivietnam.org/

The first impression from the table 7 is that the majority of the technical efficiency of the FDI firms in the four provinces is higher than the average number in 2013. However, the number of specific firms in the four provinces could be small (even in Ba Ria Vung Tau, there are no observed FDI firms in electronic and automobile industry); then the results could be biased and insignificant. Therefore, it is unlikely to conclude that there is a correlation between the infrastructure and the technical efficiency or not. It is necessary to conduct further research with better proxy for infrastructure.

Investment activity

Sinaniet. al (2007) state that the investment activity of firms, particularly investment on the fixed assets, positively affect the technical efficiency of firms. This is similar to the conclusion of Gumbau- Alber&Moudos (2002) about the positive impact of the investment on the fixed assets on the Spanish manufacturing firms. Assume that the new technology will be integrated into new assets. Then, investment in new assets could replace the old technology with the new one. Consequently, the technical efficiency of firms should be improved.

Table 8: Correlation between technical efficiency and investment capital

Textiles		Wearing Apparel		Electronic		Automobile	
N	Correlation (p-value)	N	Correlation (p-value)	N	Correlation (p-value)	N	Correlation (p-value)
124	0.1476 (0.1019)	351	-0.1738* (0.0011)	195	0.1170 (0.1034)	112	-0.0246 (0.7967)

*Note: * 1% statistically significant; ** 5% statistically significant*
Source: Author's calculation

In Vietnam, the investment activity of the FDI firms in the four sub-sectors seems not to be effective in 2013. Investment is proxied by the total amount of the investment capital of firms in 2013. The study is unable to find significant correlation between the FDI technical efficiency and the investment activity in case of textiles, electronics and automobile sub-sectors. It is even worse in the case of wearing apparel sub-sector when we find a negative and statistically significant correlation (-0.1738) (Table 8). This finding is somehow approved by research of Vu Hung Cuong& Bui Trinh (2014) indicating that the ICOR of the FDI sector is quite larger than this of the state and the non-state sector (10.10; 8.20 and 2.54 respectively). In other words, investment activity of FDI firms seems not to be effective. However, this finding is possibly biased because the efficiency of investment activity should be assessed after a period of time, not in one year. In addition, data on total amount of the investment capital of some observed FDI firms in 2013 are missing and then number of observations decreased comparing to the previous parts. Therefore, this finding should be seen as basis for further studies.

Conclusion

It is noteworthy that there are two necessary conditions to convert the FDI spill-overs into benefit of a host country: efficient operation of FDI firms and decent FDI absorptive capacity of domestic firms. This study only focuses on the former condition premising that if the FDI firms operate more efficiently, they could bring more positive spill-over effects to the domestic ones. Consequently, the results of this study will be a background for further studies on the FDI absorptive capacity.

The study examines efficiency of the FDI firms by estimating the technical efficiency from the stochastic frontier production model. In order to estimate the technical efficiency of a firm, it is assumed that all firms could use the same type of technology. Therefore, it does not make sense to estimate the production function of the Vietnam manufacturing sector as a whole because there are many sub-sectors within it. Hence, the study only chooses 04 sub-sectors that have contributed significantly to the growth of manufacturing sector over time, they are: textiles, wearing apparel, electronic and automobile. The study also compares the technical efficiency of the FDI firms to the domestic firms as well as analyses some influential factors of the FDI technical efficiency.

Here are some main concluding remarks: In general, technical efficiency of all type of firms has increased from 2009 to 2013. As expected, the FDI firms have higher level of the technical efficiency than the domestic ones. However, average technical efficiency of the FDI firms in the four sub-sectors is only smaller than 60%. In other words, the FDI firms could improve their efficiency by 40% without upgrading technology level. It could also be understood that the workers in these FDI firms are only making use of 60% of technology level. In addition, the study finds several positive influential factors of the FDI technical efficiency including the ratio of the net returns to the number of employment and the exporting activities. Regarding the firm’s age, although it positively correlates with the TE of FDI, the link in textiles and electronic sub-sectors is quite weak. Unfortunately, the author is unable to find a correlation between the technical efficiency and the infrastructure and the investment.

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Legislation

Decision no. 879.QD – TTg dated 9th June, 2014 on approving the strategy on Vietnam's industrial development through 2025, with a vision toward 2035.

Appendices

Table 9: Correlation between technical efficiency and Y/L and K/L

	Textiles		Wearing		Electronic		Auto	
	N	TE (p-value)	N	TE (p-value)	N	TE (p-value)	N	TE (p-value)
Net returns/ employment	310	0.87* (0.000)	639	0.92* (0.000)	279	0.93* (0.000)	172	0.89* (0.000)
Capital/ employment	310	0.02 (0.715)	639	-0.05 (0.230)	279	-0.015 (0.795)	172	0.04 (0.586)

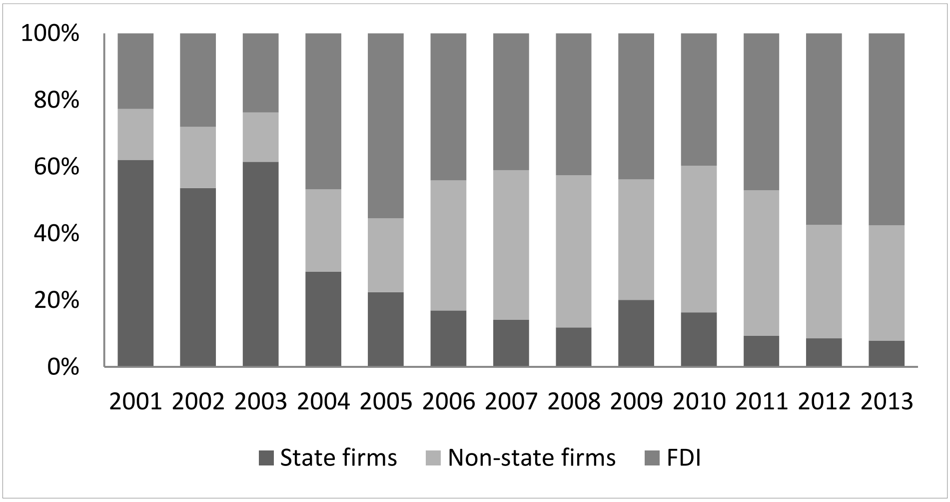
Note: 1% statistical significant*
Source: Author's calculation

Table 10: Foreign direct investment projects licensed by kinds of economic activity (Accumulation of projects having effect as of 31/12/2013).

Kinds of economic activity	Number of projects	Total registered capital (Mill. USD) (*)
TOTAL	17768	252716
Agriculture, forestry and fishing	528	3721.8
Mining and quarrying	87	3375.3
Manufacturing	9600	141406.7
Electricity, gas, stream and air conditioning supply	98	9774.8
Water supply, sewerage, waste management and remediation activities	38	1348.5
Construction	1166	11400.4
Wholesale and retail trade; Repair of motor vehicles and motorcycles	1383	4030.7
Transportation and storage	448	3755.3
Accommodation and food service activities	371	11193.6
Information and communication	1095	4124.9
Financial, banking and insurance activities	82	1332.4
Real estate activities	453	48279.8
Professional, scientific and technical activities	1698	1797.4
Administrative and support service activities	131	211.6
Education and training	204	819.9
Human health and social work activities	97	1754.6
Arts, entertainment and recreation	148	3634.2
Other service activities	141	754.1

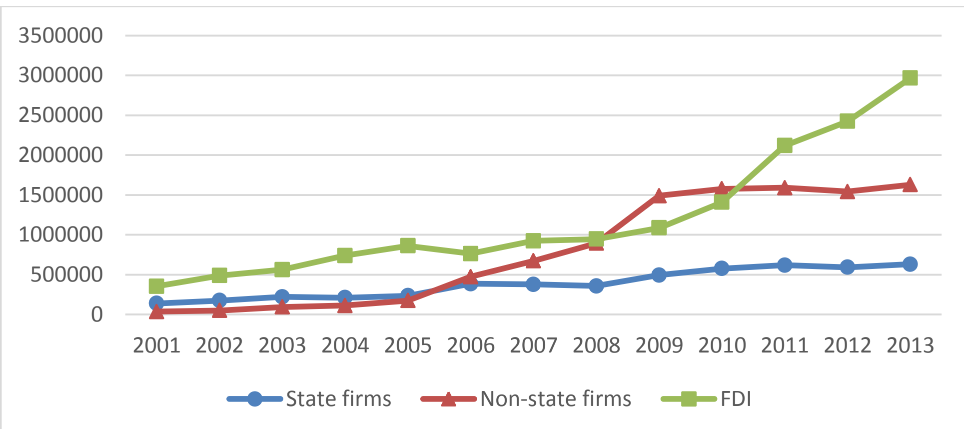
Source: Vietnam General Statistic Office, 2014

Figure 3: Proportion of capital in the manufacturing sector by type of ownership 2001-2013 (%).



Source: Vietnam General Statistic Office, 2014

Figure 4: Value added created by State, Non-state and FDI firms 2001 - 2013 (based on2001 price, mil. VND)



Source: Vietnam General Statistic Office, 2014

Table 11: Summary of variables (million VND for K, Y and worker for L)

		2013			2012			2011			2010			2009		
		Y	L	K	Y	L	K	Y	L	K	Y	L	K	Y	L	K
Textiles	Obs	2,140	2,140	2,140	2,048	2,048	2,048	1,687	1,687	1,687	1,708	1,708	1,708	1,575	1,575	1,575
	Mean	76,911	92	30,212	70,976	87	28,312	84,072	109	34,420	57,420	98	28,097	46,705	110	28,310
	SD	554,644	293	347,306	495,341	284	320,338	552,451	299	353,967	349,691	269	249,842	258,980	337	239,704
Wearing apparel	Obs	4,266	4,266	4,266	4,284	4,284	4,284	2,934	2,934	2,934	3,465	3,465	3,465	3,000	3,000	3,000
	Mean	43,361	254	9,277	35,113	226	8,207	45,736	306	10,623	27,680	230	8,470	23,365	256	8,110
	SD	186,885	718	35,010	154,469	641	32,716	166,236	718	34,834	103,976	606	32,753	89,035	717	28,740
Electronic	Obs	657	657	657	617	617	617	482	482	482	510	510	510	543	543	543
	Mean	1,164,932	465	113,214	769,072	451	81,603	550,647	470	90,208	274,494	252	57,126	148,400	202	39,115
	SD	19,900,000	2,189	685,392	11,000,000	1,927	402,272	5,945,381	1,679	341,598	1,929,443	1,061	219,693	1,047,892	939	160,119
Auto	Obs	364	364	364	359	359	359	331	331	331	305	305	305	294	294	294
	Mean	341,736	269	70,897	292,531	234	64,589	293,343	239	61,140	230,165	163	44,973	224,581	173	43,647
	SD	1,364,178	885	160,889	1,108,407	723	146,349	1,084,493	689	129,547	1,007,074	288	100,456	852,379	632	104,521

Source: Author's calculation

Table 12: Number of observation (unit: firm)

		2009	2010	2011	2012	2013
Textiles	DE	1309	1422	1353	1743	1830
	FDI	266	286	334	305	310
Wearing Apparel	DE	2440	2865	2305	3674	3627
	FDI	560	600	629	610	639
Electronic	DE	382	320	247	373	378
	FDI	161	510	235	244	279
Automobile	DE	163	162	172	202	192
	FDI	131	143	159	157	172

Source: Author's calculation

Table 13: One-sided generalized likelihood-ratio test

H0: sigma_u=0	Chibar2 (01) value							
	Textiles		Wearing Apparel		Electronic		Automobile	
	DE	FDI	DE	FDI	DE	FDI	DE	FDI
2009	101.12*	27.19*	174.57*	20.24*	30.36*	6.79*	3.1	21*
2010	120.82*	60.96*	173.84*	8.15*	18.09*	9.40*	14.63*	20.05*
2011	68.69*	34.90*	96.77*	21.96*	24.42*	20.45*	5.31**	12.40*
2012	72.67**	23.07*	163.65*	22.97*	9.29*	5.54**	12.28*	75.16*
2013	44.95*	22.77*	189.44*	5.36**	25.88*	9.44*	0.17	30.28*

*Note: Critical value of chi2(1) is 3.8415, *****statistically significant at 1%, ** statistically significant at 5%*
Source: Author's calculation

Table 14: Test for functional form

		2013			2012			2011			2010			2009		
		Chi2	P>chi2	Function	Chi2	P>chi2	Function	Chi2	P>chi2	Function	Chi2	P>chi2	Function	Chi2	P>chi2	Function
Textiles	DE	1.41	0.7020	Cobb-Douglas	9.73	0.0210	translog	21.65	0.0001	translog	7.23	0.0650	Cobb-Douglas	14.97	0.0018	translog
	FDI	19.07	0.0003	translog	15.67	0.0013	translog	25.66	0.0000	translog	18.68	0.0003	translog	27.9	0.0000	translog
Wearin.	DE	11.44	0.0096	translog	6.24	0.1006	Cobb-Douglas	43	0.0000	translog	7.32	0.0624	Cobb-Douglas	10.86	0.0125	translog
	FDI	5.53	0.1368	Cobb-Douglas	9.5	0.0233	translog	16.55	0.0009	translog	5.12	0.1633	Cobb-Douglas	11.09	0.0113	translog
Electro.	DE	14.69	0.0021	translog	18.19	0.0004	translog	3.75	0.2902	Cobb-Douglas	0.65	0.0507	Cobb-Douglas	4.3	0.2313	Cobb-Douglas
	FDI	18.19	0.0004	translog	6.76	0.0801	Cobb-Douglas	21.09	0.0001	translog	7.78	0.0001	translog	7.78	0.0001	translog
Auto.	DE	6.43	0.0925	Cobb-Douglas	8.31	0.0401	translog	8.88	0.0309	translog	1.41	0.2433	Cobb-Douglas	13.7	0.0033	translog
	FDI	7.19	0.0662	Cobb-Douglas	23.47	0.0000	translog	27.25	0.0000	translog	31.6	0.0000	translog	11.69	0.0085	translog

Source: Author's calculation

Table 15: F-test for jointly significance of variables in the model

H0: variables are not jointly significant		Textiles		Wearing Apparel		Electronic		Automobile	
		DE	FDI	DE	FDI	DE	FDI	DE	FDI
2009	Chi2	1291*	602*	2245*	1004*	281*	281*	385*	387*
	Df	5	5	5	5	2	2	5	5
2010	Chi2	1834*	804*	2744*	1114*	209*	1126*	373*	584*
	Df	2	5	2	2	2	2	2	5
2011	Chi2	1789*	826*	3121*	1108*	343*	740*	562*	606*
	Df	5	5	5	5	2	5	5	5
2012	Chi2	1219*	602*	4462*	1633*	414*	846*	521*	780*
	Df	5	5	2	5	5	2	5	5
2013	Chi2	2351*	773*	5627*	1707*	469*	870*	583*	554*
	Df	2	5	5	2	5	2	2	2

*Note: Critical value of chi2(2) and chi2(5) are 9.210 and 15.086 respectively, *denotes for statistically significant at 1%*
Source: Author's calculation

Table 16: Test difference in mean value among four aged-groups

H0: difference amongst groups =0	Source	SS	df	MS	F	Prob> F
Textiles	Between groups	0.217397	3	0.072466	2.62	0.0507***
Wearing apparel	Between groups	0.242308	3	0.080769	12.04	0.0000*
Electronic[5]	Between groups	0.119199	3	0.039733	2.06	0.1056
	Between 2 groups	0.086627	1	0.086627	3.59	0.0599***
Auto	Between groups	0.25493	3	0.084977	4.56	0.0043*

**1% statistically significant, ** 5% statistically significant, ***10% statistically significant*
Source: Author's calculation

[5] Mean values of technical efficiency among 04 groups are not statistically different (0.1056) but mean values between group 1(less than 5 years) and group 4(more than 15 years) are statistically different at 10% (0.0599)

Table 17: Test difference in mean value between exporting and non-exporting group

H0: difference among groups = 0	Textiles	Wearing apparel	Electronic	Automobile
N	310	639	279	172
t	t = 7.2171	t = 3.7355	t = 1.9666	t = 3.2546
(Pr(|T| > |t|))	0.0000*	0.0002*	0.0002*	0.0014*

**1% statistically significant, ** 5% statistically significant, ***10% statistically significant*
Source: Author's calculation

Table 18: P-value of prediction squared

	Textiles		Wearing Apparel		Electronic		Automobile	
	DE	FDI	DE	FDI	DE	FDI	DE	FDI
2009	0.96	-1.0976	-0.1768	-0.4505	-0.8524	-0.4624	0.498	0.612
2010	0.421	0.961	1.8375	2.2468	-0.4723	-0.4686	1.4539	-1.5915
2011	-0.2157	-0.4932	0.479	0.477	-0.631	0.987	-1.0266	0.796
2012	-0.4346	-0.7643	0.876	1.5895	0.97	0.17	-0.2081	-11833.2
2013	0.3475	-0.3697	-0.4514	1.7866	0.3405	0.4385	0.786	0.99

Source: Author's calculation