Do Direct Foreign Investments Increase Efficiency Convergence at Firm Level? The Case of Vietnam, 2000-2011

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ABSTRACT

The objective of this study is to assess the extent to which the effect of FDI on firms' efficiency and efficiency convergence across industries in Vietnam. Dynamic input output tables are used to construct the linkages between domestic and foreign firms. Stochastic production frontier is used to estimate firms 'efficiency with a large panel dataset covering manufacturing firms in Vietnam from 2000 to 2011. The analysis shows that, the impact of FDI on domestic firms 'efficiency score and convergence at firms' level through the horizontal, backward and supply backward channels are negative and different.

I. Introduction

The literature investigating the relationship between FDI and technical efficiency has been focusing on technological spillover effects resulting from foreign direct investment firms. The question of how domestic firms benefited from the presence of FDI in terms of spillover effects? To answer this question, the literature have used a combined empirical method for studying technical efficiency using micro data (Schmidt & Sickles (1984), Cornwell & et al. (1990), Haddad and Harrison (1993), Kathuria V. (2000) and Ghali and Rezgui (2006). In some case, the contribution of FDI via spillovers have been confirmed while in others, it has been rejected, depending on the nature of the data used and also on specific empirical methodologies.

Technical efficiency has been measured and interpreted in different ways. The literature offers a large choice of methodologies, each one with its strengths and weaknesses. Two important points emerged from their literature review and the comparative studies performed by Gong and Sickles (1992) about the DEA method and the stochastic frontier approach. In this paper, we focus on the stochastic frontier approach.

Our objective, beyond presenting evidence of technical inefficiency and FDI's spillover effects is to investigate whether technical efficiency convergence process occurred in the presence of FDI through spillovers to firms. Cross-country productivity convergence have received attention both at the country level (Dollar and Wolff (1988); Dorwick and Nguyen (1989), and at the industry level (Baumol (1986); Bernard and Jones (1996). It should be noted that the growth of a country results from the growth of industries, which comes from the growth of firms. Ultimately, the improvement in technical efficiency is an important aspect of the process of growth. However, there has been little empirical work at the firm level on technical efficiency convergence (Alam and Sickles, 2000.

Our methodology proceeds in four steps. First, we construct an empirical representation of the frontier technology for a given set of sub- industries. This can be accomplished through econometric estimation techniques. Second, we discuss the results on a statistical base in order to see if FDI spillovers could be sensitive to any change in technical efficiency measures. Third, we analyze technical efficiency spillovers of FDI in a sample of Vietnamese enterprises. Our analysis extends the literature in the way of testing for the presence of vertical and horizontal spillovers on the firms' technical efficiency. Finally, we estimate

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convergence regressions to determine the degree of firms' technical efficiency convergence and firms' technical efficiency convergence in the presence of spillover effects from FDI through horizontal and vertical spillovers.

We apply this methodology to the total sample of sub-industry in Vietnamese manufacturing industry (sub-industries includes (1) food products and beverages and tobacco products; (2) textiles and wearing apparel; (3) footwear and (4) wood and wood products) and the sample of domestically owned firms in this sub-industry.

This paper is organized into four sections as follows. The next section presents methodology. Section 3 describes the data, reports the estimation results of the models and discusses the results obtained in this paper, with special emphasis on the differences in the speed of convergence. The final section concludes the paper.

II. Methodology

2.1. Overview of FDI Spillover Channels

Horizontal spillovers of FDI take place when the presence of FDI increases the firms' efficiency in the same industry. Spillovers can occur through the demonstration effect; channel of labor turnover and the channel of competition effect. The net horizontal effect of FDI on domestic firms is inconclusive, depending on the relative magnitudes of the positive technological spillovers and negatively crowding out effect. They can be defined as:

Horizontal ($Hori_{jt}$) captures the extent of foreign presence in subsector *j* at time *t* and is defined as a foreign equity participation averaged over all firms in the sector, weighted by each firm's share in sectoral output . In other words,

$$Hori_{jt} = \frac{\sum_{j \in J} Sf_{ijt} * X_{ijt}}{\sum_{j \in J} X_{ijt}}$$

Sf_{ijt} (Foreign share) is define as the share of firm *i*'s total equity owned by foreign investors, and X_{ijt} is its output, for i^{th} firms in sector *j* at time *t*.

Backward ($Back_{jt}$) is a proxy for the foreign presence in the industries that are being supplied by the sector to which the firm in question belongs and thus is intended to capture the extent of potential contacts between domestic suppliers and foreign – owned firms. It is defined in the following way:

$$Back_{jt} = \sum_{k \ if \ k \neq j} \gamma_{jkt} Hori_{kt}$$

where γ_{jkt} is the proportion of sector *j*'s output supplied to sourcing industry *k* at time *t* taken from the input-output table at the two-digit level. The proportion is calculated excluding products supplied for final consumption but including imports of intermediate products. As the formula above, inputs supplied within the sector are not included, since this effect is already captured by the *Horizontal* variable.

Forward (Forw): The same way, we define the Forward spillover variable $Forw_{jt}$ as

$$Forw_{jt} = \sum_{l \ if \ l \neq j} \delta_{jlt} Hori_{lt}$$

Where the Input - Output tables reveal the proportion δ_{jlt} of industry *j*'s inputs purchased from upstream industries *l*. Input purchased within the industry (*l≠j*). Thus the greater the foreign presence in sectors supplied by are also excluded, since this is captured by Horizontal.

Supply backward (denoted by $Sback_{lt}$*)* which captures the hypothesis of Markusen and Venables is defined as:

$$Sback_{jt} = \sum_{i\ if\ l \neq j} \delta_{jlt} Back_{lt}$$

Where δ_{jlt} -the proportion of industry *j*'s inputs is purchased from upstream industries *l* that in turn supply the downstream industries of foreign firms as measured by variable $Back_{jt}$.

2.2. Efficiency Measurement

2.2.1. Stochastic Frontier Approach

To estimate firms' technical inefficiency Applying the stochastic production frontier approach, this paper assumes that the sub-industry is a function of two inputs, including capital and labor. The components of productivity change can be estimated within a stochastic frontier approach, and the time-varying production frontier can be specified in translog form as:

$$\ln y_{it} = \alpha_0 + \sum_j \alpha_j \ln x_{jit} + \alpha_T t + \frac{1}{2}\sum_j \sum_l \beta_{lj} \ln x_{lit} \ln x_{jit}$$
$$+\frac{1}{2}\beta_{tt} t^2 + \sum_j \beta_{tj} t \ln x_{jit} + v_{it} - u_{it}, \quad j, l = K, L \qquad [1]$$

In the equation above, y_{it} is the observed output, t is the time variable and x represents for inputs, subscripts j and l are index for inputs (j, l= K, L). The efficiency error u accounts for production loss due to unit-specific technical inefficiency and the value of u is always greater than or equal to zero; and it is assume to be independent of the etatistical error, v.

This methodology also assumed that u is independent of the random error v, which is holds usual properties.

$$u_{it} = u_i \exp[-\eta(t-T)] \qquad [2]$$

In equation [2], the unknown parameter η represents the rate of change in technical inefficiency, and the non-negative random variable u_i is the technical inefficiency effect for the i^{th} firm in the last year for the data set. This means that the technical inefficiency effects in earlier periods are a deterministic exponential function of the inefficiency effects for the corresponding forms in the final period *(i.e.* $u_{it} = u_i$ given that data for the i^{th} firm are available in period t). A firm with a positive γ is likely to improve its level of efficiency over time and vice-verse. A value of η=0 that there is no time-effect.

Since the estimates of technical efficiency are sensitive to the choice of distribution assumptions, we consider truncated normal distribution for general specifications for one-sided error u_{it}, and half-normal distribution can be tested by LR test.

Given the estimates of parameters in Equation [2] and [3], the technical efficiency level of a firm at time t is defined as:

$$TE_{it} = exp(-u_{it}) \qquad [3]$$

Technical efficiency estimated from this model is denoted by TE.

2.3. Sources of inefficiency and the role of foreign firms

To examine the correlation between firm inefficiency and foreign presence in the same industry (intra-industry or horizontal spillovers) and spillovers to firms in linked industries (inter-industry or vertical spillovers) at firm level of some sub-industries in Vietnamese manufacturing industry. We estimate several variations of the following equation:

$$\ln y_{ijt} = \alpha_0 + \alpha_L \ln L_{ijt} + \alpha_K \ln K_{ijt} + \alpha_t t + \frac{1}{2}[\beta_{LL}(\ln L_{ijt})^2 + \beta_{KK}(\ln K_{ijt})^2]$$
$$+\beta_{tL} t(\ln L_{ijt}) + \beta_{tK} t(\ln K_{ijt}) + \beta_{KL}(\ln K_{ijt})(\ln L_{ijt}) + \frac{1}{2}\beta_{tt} t^2$$
$$+\delta_0 + \delta_1 Sf_{jt} + \delta_2 hori_{jt} + \delta_3 Back_{jt} + \delta_4 Forw_{jt} + \delta_5 Sback_{jt} + \delta_6 Herf_{jt} +$$
$$\delta_7 \left(\frac{K}{L}\right)_{ijt} + \delta_8 Lc_{ijt} + \delta_9 vng_{ijt} + v_{ijt} - u_{ijt};\ j \in J. \qquad [4]$$

Where y_{it}, *K, L, t* were defined in [1]. *Sf, Hori, Forw, Back and Sback* variables are used to account for the spillover effects from FDI to domestic firms' technical efficiency. (*K/L*) is the capital labor ratio. Per capita income (*Lc*) approximate for labor quality and *vng* is defined as: $vng_{ijt} = 1 - \frac{K_{ij(ownship)}}{K_j}$, where K_j is capital of sub-industry *j*.

Subscripts j refer to four sub-industries, namely: food products and beverages (F); textile (T); wearing apparel (W); footwear and manufacture of wood and products of wood (WD), and $\mathrm{J} = \{\mathrm{F,\ T;\ W;}WD\}$.

2.4. Efficiency Convergence among Firms

2.4.1.Unconditional convergence

Following Alam and Sickles (2000), we regress average growth rates on a constant and the initial technical efficiency levels. The basic form of the equation of unconditional convergence is:

$$\frac{1}{T}[\ln TE_{i,final} - \ln TE_{i,initial}] = \alpha + \beta \ln TE_{i.initial} + \varepsilon_t, \qquad [5]$$

where T is number of years considered; *TE* is technical efficiency on the designated year for the firm *i* and catch-up is denoted by a negative coefficient of β. The speed of catching up is: $\lambda = 1 - (1 + \beta T)^{1/T}$.

2.4.2.Conditional Convergence

To consider whether technical efficiency from SFA model convergence occurred in the presence of FDI through spillovers to domestic firms. Since, it may take more time before FDI's spillovers effects on domestic firms' technical efficiency, we include lagged foreign share (*Sf*), Horizontal (*Hori*), Backward (*Back*), Forward (*Forw*) and supplybackward (*Sback*) linkage measures into the model . The new equation of conditional convergence is:

$$\frac{1}{T}[\ln TE_{i,final} - \ln TE_{i,initial}] = \alpha + \beta \ln TE_{i.initial} + \sum_{t=2000}^{2011} \delta_t^{(1)} Sf_{jt} + \sum_{t=2000}^{2011} \delta_t^{(2)} Hori_{jt}$$
$$+ \sum_{t=2000}^{2011} \delta_t^{(3)} Back_{jt} + \sum_{t=2000}^{2011} \delta_t^{(4)} Forw_{jt} + \sum_{t=2000}^{2011} \delta_t^{(5)} Sback_{jt} + \varepsilon_t \qquad [6]$$
$$t = 2000, 2001, \ldots, 2011; i, j \in J = \{\mathrm{F,\ T;\ W;}WD\}$$

where subscripts i, and t refer to firm and time respectively. The purpose of our study is to examine spillover effects stemming from the activities of foreign firms on the technical efficiency convergence in the sub-industry. Then the key variables in the unconditional convergence model are the foreign share (*Sf*) Horizontal (*Hori*), forward (*Forw*), backward (*Back*) and supply backward (*Sback*) linkages from the presence of foreign firms.

III. Data and Estimated Results

3.1. Data

Our analysis is based on the data from annual enterprise survey conducted by the Vietnam General Statistical Office. The survey covers both manufacturing and non-manufacturing firms. Industry data is available at a 4-digit level. From this survey, we develop a longitudinal panel data set for the years from

2000 to 2011. We drop the firms from our sample set for which the firm-age (the year of the survey minus the year of establishment), total wages, tangible assets, and/or the number of workers are not positive and in cases with incomplete replies.

We also drop firms' which enter or exit between year 0 and year T. We select "survivor" firms being survivors that continue to stay in the market between year 2000 and year 2011. The number of firms in our sample is 1038 observations and the sample of domestic firms is 907 observations for each year.

To avoid a bias, we estimate efficiency using SFA model for the total sample, denoting SFAT and for the sample of domestically owned firms, denoting SFAD model. Technical efficiency scores ,estimated from SFAT and SFAD models are called TET and TED, respectively.

3.2. Empirical Results from Stochastic Production Frontier

The results can be summarized as follows.

Hypothesis tests: This paper uses Frontier 4.1 program to estimate parameters in the stochastic production function in equation [2] via maximum-likelihood method. Although this program does not directly estimate σ_u^2 and σ_v^2, it will provide the value of:

$$\gamma = \sigma_u^2 / \sigma^2 \text{ , } \sigma^2 = \sigma_u^2 + \sigma_v^2 \qquad [7]$$

This parameter will be listed in the result table and must take the value between zero and one. If hypothesis $\gamma = 0$ is accepted, this means that σ_u^2 is equal to zero; therefore, the efficiency error term should be removed from the model. Conversely, if γ is equal to one, the model will be full – frontier function; hence, the stochastic term should not be used in the model.

To conduct hypothesis tests, this paper uses LR test with generalized likelihood ratio statistics λ. The formula of λ is given as following:

$$\lambda = -2[L(H_0) - L(H_1)]$$

Where $L(H_0)$ is the value of the likelihood function for the frontier model with the parameter restrictions specified by the null hypothesis H_0, and $L(H_1)$ is the value of the likelihood function for the general frontier model.

Table 1 shows the hypothesis test results for total sample of sub-industry and the sample of domestically owned firms (or domestic firms)

Table 1. Generalized likelihood ratio of hypothesis for parameters of the SFA for models of sub-industry and domestically owned firms

Hypotheses	Log-likelihood value	Test statistics	Critical value		Decision
			1%	5%	
(1) Cobb-Douglas production function, H_0: all β_s are equal to zero (df = 6)					
Total sample (SFAT)	-17484.4	390.14	16.81	12.59	Reject
Domestic firms (SFAD)	-15482.3	399.9	16.81	12.59	Reject
(2) No technical inefficiency, $H_0: \mu = \eta = \gamma = 0$ (df = 3)					
Total sample (SFAT)	-19244	3815	10.501	7.045	Reject
Domestic firms(SFAD)	-16886.5	3148	10.501	7.045	Reject
(3) No technical change, $H_0: \alpha_t = \beta_{tL} = \beta_{tK} = \beta_{tt} = 0$ (df = 4)					
Total sample (SFAT)	-17396	215	13.28	9.49	Reject
Domestic firms (SFAD)	-15390.9	157.3	13.28	9.49	Reject
(4) Neutral technical progress: $_0: \beta_{tL} = \beta_{tK} = 0$ (df = 2)					
Total sample (SFAT)	-17365	157	9.21	5.99	Reject
Domestic firms (SFAD)	-15333.2	41.9	9.21	5.99	Reject
(5) Half-normal distribution of technical inefficiency, $H_0: \mu = 0$ (df = 1)					
Total sample (SFAT)	-17289	352	6.63	3.84	Reject
Domestic firms (SFAD)	-15312.2	12	6.63	3.84	Reject
(6) Time invariant technical inefficiency, $H_0: \eta = 0$ (df = 1)					
Total sample (SFAT)	-17113	37.7	6.63	3.84	Reject
Domestic firms (SFAD)	-15138.9	42.13	6.63	3.84	Reject

Source: Authors' estimates from the data source.

The first null hypothesis states that the technology in Vietnamese sub-industry is a Cobb – Douglas *($H_0: \beta_{KK}$* $= \beta_{LL} = \beta_{KL} = \beta_{tK} = \beta_{tL} = \beta_{tt} = 0$), is rejected at 1% significance level for all samples, which means that the production function is Cobb – Douglas function, is rejected at all samples. Therefore, the translog production function is more adequate than Cobb – Douglas function to apply for the data set.
The second null hypothesis is that there are no technical inefficiency effects: ($H_0: \mu = \eta = \gamma = 0$), is rejected at 1% significance level for all samples. Therefore, technical inefficiency is existence in this industry.
The third null hypothesis is that there is no technical change ($H_0: \alpha_t = \beta_{tL} = \beta_{tK} = \beta_{tt} = 0$, is rejected at 1% significance level for all samples. Thus, technical change is existence in this industry.
The fourth null hypothesis is that the technical progress is neutral ($H_0: \beta_{tL} = \beta_{tK} = 0$), is rejected at 1% significance level for all samples. Although the translog stochastic frontier function allows non-neutral technical progress, all samples strongly reject this null hypothesis. This implies that there is non-neutral technical progress in the data sets of our sample.
The fifth null hypothesis that there is existence of half-normal distribution of technical inefficiency ($H_0: \mu = 0$), is rejected at 1% significance level for all samples. This implies that the distribution of technical inefficiency is truncated rather than half-normal.
The sixth null hypothesis that technical inefficiency is time-invariant ($H_0: \eta = 0$), is also rejected at 1% significance level for all samples.

Table 2: Estimation of stochastic frontier production and technical inefficiency model

	Model for total sample of sub-industry (SFAT)		the sample of domestically owned firms (SFAD)	
	stochastic frontier model (model 1)	Inefficiency model (model 2)	stochastic frontier model (model 3)	Inefficiency model (model 4)
	Coefficient	Coefficient	Coefficient	Coefficient
Cons (α_0)	3.961*** (0.156)	2.112*** (0.141)	3.894*** (0.166)	1.329*** (0.143)
lnK (α_K)	0.336*** (0.038)	0.467*** (0.045)	0.322*** (0.042)	0.593*** (0.040)
LnL (α_L)	0.925*** (0.046)	0.667*** (0.048)	0.942*** (0.051)	0.661*** (0.043)
T (α_T)	-0.006 (0.015)	0.021 (0.019)	0.006 (0.016)	0.025 (0.017)
$(LnK)^2$ (β_{KK})	0.037*** (0.004)	0.044*** (0.005)	0.044*** (0.004)	0.040*** (0.004)
$(lnL)^2$ (β_{LL})	0.036*** (0.006)	0.037*** (0.007)	0.042*** (0.006)	0.048*** (0.006)
LnKLnL (β_{KL})	-0.093*** (0.008)	-0.095*** (0.011)	-0.106*** (0.009)	-0.106*** (0.008)
tLnK (β_{tK})	0.003* (0.002)	-0.002 (0.002)	-0.002 (0.002)	-0.008*** (0.002)
tLnL (β_{tl})	0.009*** (0.002)	0.017*** (0.003)	0.013*** (0.002)	0.026*** (0.003)
t2 (β_{tt})	-0.005*** (0.001)	-0.005*** (0.001)	-0.004*** (0.001)	-0.005*** (0.001)
Cons (δ_0)		-1.556 (0.401)		0.135** (0.048)
Sf (δ_1)		-0.591** (0.198)		
Hori (δ_2)		0.487** (0.186)		0.406*** (0.081)
Back (δ_3)		-1.734*** (0.361)		-3.129*** (0.171)
Forw (δ_4)		0.182 (0.500)		-0.039 (0.169)
Sback (δ_5)		4.142** (1.451)		1.469*** (0.187)
Herf (δ_6)		2.670** (1.124)		0.128*** (0.247)
K/L (δ_7)		0.001*** (0.000)		0.0004*** (0.000)
Lc (δ_8)		-0.007*** (0.002)		-0.005*** (0.001)
Vng (δ_0)		0.001*** (0.000)		0.003*** (0.001)
σ^2	1.403*** (0.041)	1.981*** (0.408)	1.485*** (0.04)	1.24E+008*** (0.017)
γ	0.505*** (0.010)	0.503*** (0.126)	0.489*** (0.01)	2.01E-02*** (0.003)
μ	1.684*** (0.063)		1.704*** (0.073)	
η	0.013*** (0.003)		0.013*** (0.003)	

Source: Authors' estimates from the data source
Note: 1) standard errors are given in the parenthesis;
*2) */**/*** Denotes statically significant at the 10%, 5%, 1%, respectively*

Using a panel data for 1038 firms (for each year) and 907 (for each year) domestically owned firms, belonging to the Vietnamese sub-industries in manufacturing sector, observed over the period 2000-2011, we have shown statistically that FDI spillover effects is affected in the total sample for sub-industry (model 1 and 2) and sample for domestically owned firms (model 3 and 4).

Table 2 reports the estimated results with ln$y$ as the dependent variable. In the model 2, the coefficients on sf is negative and statistically significant at the 1% level. A positive explanation for this is that there is the potential negative spillover effects of FDI on domestic firms' inefficiency or the potential positive spillover effects of FDI on domestic firms' efficiency.

Horizontal coefficients in two cases (model 2 and 4) are positive and statistically significant at 5% and 1% level. It means that horizontal spillover effects on domestic firms' efficiency to be negative. It means that FDI spillover effects occur through two channels: mobility of workers trained by foreign firms and technology imitation and another channel of horizontal spillover (foreign entry) are canceling out effect on domestic competitor, leading to the significant result in our inefficiency models.

Consider the effect of backward linkage as a measure of vertical spillovers, the effect of foreign presence on downstream firms' efficiency in model (2), (4). We observe negative and statistically significant coefficient associated with backward linkage (*Back*) variable. It means that spillover effects occurring through the channel of backward linkage on efficiency's domestic firms are positive.

Forward coefficients in both models are insignificant. A possible explanation for this is that inputs produced locally by foreign firms might be more expensive and less adapted to local requirements.

Sback coefficients in both models (model 2 and 4) are both positive and significant, It means that spillover effects from the foreign firm through its local suppliers to the local customers of these suppliers are insignificant.

3.6. Convergence Results

Our empirical work considers two types of convergence. With cross sectional data, convergence involves an investigation of the relationship between growth rates and initial technical efficiency level. Unconditional (absolute), convergence exists when regressing a growth measure, such as technical efficiency growth rate, on initial technical efficiency gives a negative and significant coefficient. If other conditional variables are included, they should be jointly insignificant for absolute convergence to hold. Conditional convergence will also requires a negative coefficient on initial technical efficiency, after controlling the effects of other explanatory variables, at least some of which proved to be significant.

3.6.1. Estimated Results of Unconditional Convergence

Table 3 displays the cross-sectional OLS estimates of unconditional convergence for TET and TED models. The estimated result from TET model shows that the coefficient of initial technical efficiency is 0.0008 and significant, indicating there is no evidence for β- convergence. The coefficients of initial technical efficiency from TED model is -0.0117 and significantly different from zero at 1%, confirming the presence of unconditional convergence during the period of 2000-2011.

The speed of convergence of the TED model is significantly lower than in the previous country–level studies, Dorwick and et al (1989) reported that speed of convergence among counties was 2.5% annually, the result of TED model shows that the speed of convergence is 1.244%. It takes about 59 years for firm I to catch up to the most efficiency firm.

Table 3: Unconditional Convergence (2000-2011)
Dependent variable: The average year to year growth in the technical efficiency scores

Model	Estimated results	Speed of catching up	Year
(5)	$DLnTET_{i,2011} = \underset{(6.76E-05)}{0.0062^{***}} + \underset{(2.59E-06)}{0.0008}^{***} LnTE_{i,2000};$ $R^2 = 0.5; DW = 1.7;$ Number of Observations = 1038	There is no evidence of convergence	
(6)	$DLnTED_{i,2011} = \underset{(5.22E-06)}{0.0003^{***}} - \underset{(2.39E-06)}{0.0117}^{***} LnTE_{i,2000};$ $R^2 = 0.99; DW = 1.9;$ Number of Observations = 907	1.244%,	58.89

Source: Authors' estimates from the data source
Note: 1) standard errors are given in the parenthesis;
*2) *** Denotes significant at the 1 percent level.*

3.6.2. Estimated results of conditional convergence

To investigate whether there exist impacts of FDI's spillover effects on technical efficiency convergence, we estimate the unconditional convergence models with adding spillover variables. Table 4 presents the cross-sectional OLS estimates of conditional convergence for the total sample of sub-industry and the sample of domestic firms. We estimate two models for the total sample of sub-industry and sample of domestic firms. 60 variables conditioning in these models are $Hori_{2000}$, $Hori_{2001}$,...,$Hori_{2011}$, $Forw_{2000}$,..., $Forw_{2011}$...variables. Firstly, we consider the convergence results of technical efficiency, estimated from a stochastic production frontier. The estimated results of the models **7** is given in Table 4. The 60 conditional variables (representing impacts of FDI) were included, and 49 variables were jointly insignificant in this model. After controlling the effects of other explanatory variables, 11 variables prove to be significant. These are $Hori_{2001}$, $Hori_{2004}$, $Hori_{2005}$, $Hori_{2011}$, $Back_{2005}$, $Back_{2010}$, $Back_{2011}$, $Sback_{2000}$, $Sback_{2001}$, Sf_{2010} and $Forw_{2002}$. Consider the total effect of foreign presence through these conditional variables on the technical efficiency convergence, we observe negative and statistically significant coefficient associated with Horizontal linkage (*Hori*) variable and positive and statistically significant coefficient associated with Forward (*Forw*), Foreign share (*Sf*), Supply-backward (*Sback*) variables. However, the coefficient of initial technical efficiency is 0.0008 and significant at 1%, indicating there is no evidence for β- convergence. It is the same the estimated result of the model 1 (unconditional convergence model). We continue to consider the convergence results of technical efficiency, estimated a stochastic production frontier from the sample of domestically owned firms.

The estimated result of the model 8, is given in Table 4. The 60 conditional variables (representing impacts of FDI) were included, and 52 variables were jointly insignificant . 8 variables are significant: $Hori_{2001}$, $Hori_{2006}$, $Hori_{2010}$,, $Back_{2006}$, $Back_{2008}$, $Forw_{2003}$, $Forw_{2007}$, and $Forw_{2008}$. However, the coefficient of initial technical efficiency is -0.0117 and significant at 1%, indicating there is evidence for β- convergence. This estimated result is the same the results of the unconditional convergence model. The difference between the two estimated convergence equations from the total sample and the sample of domestic firms is in the sign of the initial technical efficiency, which was positive and significant for the total sample, but negative and significant for the sample of domestic firms.

Table 7: Conditional Convergence (2000-2011)

	(a) For total sample of sub-industry with number of observations =1038	
(7)	$\Delta \ln TE_{i,2011} = \underset{(0.0002)}{0.0055^{***}} + \underset{(2.87E-06)}{0.0008^{***}} LnTE_{i,2000} + \underset{(0.0031)}{0.0008^{***}} Sback_{j,2000}$ $+ \underset{(0.0002)}{0.0013^{***}} Hori_{j,2001} - \underset{(0.0008)}{0.0025^{***}} Sback_{j,2001} - \underset{(0.0003)}{0.0006^{***}} Forw_{j,2002}$ $- \underset{(0.0002)}{0.0006^{**}} Hori_{j,2004} - \underset{(0.0002)}{0.0009^{***}} Hori_{j,2005} + \underset{(0.0002)}{0.0005^{***}} Back_{j,2005}$ $+ \underset{(6.57E-05)}{0.0002^{**}} Sf_{j,2010} - \underset{(7.54E-05)}{0.0003^{***}} Hori_{j,2010} - \underset{(0.0001)}{0.0003^{**}} Back_{j,2010}$ $+ \underset{(0.06E-05)}{5.26E-05^{**}} Back_{j,2011}$	R^2=0.55 DW= 1.81
	(b) For domestically owned firms of sub-industry with number of observations: 907	
(10)	$\Delta \ln TED_{i,2011} = \underset{(7.17E-06)}{-0.00028^{***}} - \underset{(2.55E-06)}{0.0117^{***}} LnTED_{i,2010} - \underset{(2.92E-05)}{7.86E-05^{**}} Hori_{j,2001}$ $+ \underset{(3.61E-05)}{0.0001^{***}} Forw_{j,2003} + \underset{(2.33E-06)}{6.68E-05^{***}} Hori_{j,2006} - \underset{(2.56E-05)}{9.52E-05^{***}} Back_{j,2006} +$ $- \underset{(0.0001)}{0.0004^{**}} Forw^2_{j,2007} + \underset{(2.42E-05)}{4.50E-05^{*}} Back_{j,2008} + \underset{(0.0001)}{0.0003^{**}} Forw_{j,2008} -$ $- \underset{(1.79E-05)}{3.02E-05^{*}} Hori_{j,2010}$	R^2=0.99 DW= 1.93 Speed of catching up =1.24%

Source: Authors' estimates from the data source;
Note: 1) standard errors are given in the parenthesis;
*2) */**/*** Denotes significant at the 10, 5 and 1 percent levels, respectively.*

IV. Conclusion

This paper study the impacts of FDI on domestic firms' technical efficiency and technical efficiency convergence. Although there are numerous studies of productivity spillovers and convergence, the issue the impacts of FDI on domestic firms' efficiency and convergence efficiency have been little empirical work at the firm level. This study fills this gap between theory and empirical work. Our findings are summarized as follows: Firstly, we introduced vertical and horizontal channels in the convergence model. Secondly, we found that there are impacts of FDI spillover effects on domestically owned firms. However, the channels of horizontal and supply backward, forward spillover effects are canceling out positive effect on domestic firms.

Thirdly, the estimated result of convergence model using total sample, shows that there is no evidence for β-convergence but the convergence result of the model using domestically owned firms is significantly.

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