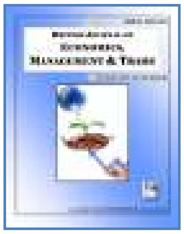

British Journal of Economics, Management & Trade
5(2): 172-180, 2015, Article no.BJEMT.2015.015
ISSN: 2278-098X

SCIENCEDOMAIN ***international***
www.sciencedomain.org

FDI and Efficiency Convergence, the Case of Vietnamese Manufacturing Industry

Nguyen Khac Minh[1*], Nguyen Viet Hung[2], Ha Quynh Hoa[2] and Pham Van Khanh[3]

[1]Department of Economics, Water Resources University, 175 Tay son Street, Dong Da District, Hanoi, Vietnam.
[2]Faculty of Economics, National Economics University (NEU), 207 Giai Phong Street, Hai Ba Trung District, Hanoi, Vietnam.
[3]Faculty of Information Technology, Military Technical Academy (MTA), 236 Hoang Quoc Viet Street, Cau Giay District, Hanoi, Vietnam.

Authors' contributions

This work was carried out in collaboration between all authors. Authors NKM and NVH designed the study, performed the statistical analysis and wrote the first draft of the manuscript. Author HQH managed the analyses of the study. Author PVK managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJEMT/2015/12687
Editor(s):
(1) Chen Zhan-Ming, School of Economics, Renmin University of China, Beijing, China.
Reviewers:
(1) Nurulizwa bte Abdul Rashid, Faculty of technology and Technopreneurship, UTeM & Malaysia.
(2) Sergey A. Surkov, International Institute of Management LINK, Russia.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=686&id=20&aid=6255

Case Study

Received 13th July 2014
Accepted 9th September 2014
Published 28th September 2014

ABSTRACT

Aims: The scope of this study is twofold. We aim to test efficiency convergence hypothesis among firms in Vietnamese manufacturing industry, and to analyze the influence of foreign direct investment (FDI) on efficiency and efficiency convergence.
Study Design: Case study
Place and Duration of Study: Technical efficiency measures are derived for a sample of Vietnamese manufacturing firms during 2000-2012
Methodology: nonparametric data envelopment analysis (DEA). The approach to find the impacts of FDI on efficiency and efficiency convergence through horizontal and vertical spillover effects is to construct the linkages from dynamic input - output tables. The way to test unconditional convergence in the two technical efficiency measures from DEA is used the regression in the form

**Corresponding author: Email: khacminh@gmail.com; hungnv.neu@gmail.com;*

of the Barro equation. The same approach is employed in order to test the influence of FDI as conditioning factor over firms' efficiency.

Results: We find the evidence that increase foreign presence within an industry rises the speed of convergence, and impact of FDI on efficiency and efficiency convergence through channels and time are quite different.

Conclusion: The existence and the nature of the effect of FDI on firms' efficiency and efficiency convergence at firms levels in the sub- industries: (1) There were impact of FDI on domestic firms' efficiency score and convergence at a firm level; (2) The presence of FDI increased the speed of efficiency convergence in domestically owned firms.

Keywords: Data Envelopment Analysis (DEA); Free Disposal Hull (FDH); manufacturing; Efficiency; Foreign Direct Investment (FDI); convergence.

1. INTRODUCTION

The literature investigating the relationship between FDI and technical efficiency has been focusing on technological spillover effects resulting from foreign direct investment. In some case, the contribution of FDI to technical efficiency and TFP 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.

Our objective, beyond presenting evidence of technical inefficiency and FDI's spillover effects via horizontal and vertical linkages[1], is to investigate whether technical efficiency convergence process occurred in the presence of FDI through spillover effects in some sub-industries of Vietnamese manufacturing industry[2]. Sub-industries in Vietnamese manufacturing industry include (1) food products and beverages and tobacco products (F); (2) textiles and wearing apparel (T); (3) footwear (W) and (4) wood and wood products (WD) and the sample of domestically owned firms in those sub-industries.

Cross-country productivity convergence have received attention both at the country level [1]; and at the industry level [2]. 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 [3].

This paper is organized into four sections as follows. The next section sets out the theoretical framework underlying the empirical analysis and results. Section 3 describes the data, reports the estimation results of the models and discusses the results obtained, with special emphasis on the contributions of FDI to increase the speed of convergence. The final section concludes the paper.

2. METHODOLOGY

Our methodology proceeds in three steps. First, we construct an empirical representation of the frontier technology. Second, we set out the models for analyzing the influence of foreign direct investment. Finally we present the models for testing unconditional convergence and conditional convergence for a given set of sub-industries.

2.1 Efficiency Measurement

The production technology H^t for the transformation of inputs, $x_t \in R_+^N$ into outputs, $y_t \in R_+^K$, at for each time period t=1,2,…T can be defined as:

$$H^t = \{(x_t, y_t) : x_t \ can\ produce\ y_t\},$$

Where H^t is assumed to satisfy certain axioms to define meaningful output distance functions. The efficiency scores are the distances from the frontier. An output- based distance function can

[1] *Horizontal spillovers run from a foreign firms to a local firms in the same industry. On the other hand, vertical spillovers refers to local firms that may be able to improve their productivity (efficiency) as a result forward or backward linages with foreign firms (see Blomstrom and Kokko [15]). Forward spillover: domestically owned firms gain access to less costly intermediate inputs from FDI in upstream industries, while Backward spillovers of FDI refer to the technology transfer through supply chain from FDI to domestic supplier.*

[2] *Vietnamese manufacturing sector is the most important sector in the country in terms of its contribution to economic growth. Four sub-industries: food products and beverages and tobacco products; textiles and wearing apparel; footwear and wood and wood products have contributed about more than 40% of Vietnamese manufacturing industries' total output during 2006-2013.*

be defined as:

$$D(x,y) = Min\{\theta : (x, y/\theta) \in H\} = \{Max[(x\ \theta y) \in H]\}^{-1} = [D(x,y)]^{-1}$$

The distance function is defined as the inverse of the maximal proportional increase of output vector y, given input x. It is also equivalent to the reciprocal of [4] measure of output efficiency. An output – inefficient firm has *D(x ,y)*<1. In the case of the non-parametric method, we use the methods of data envelopment analysis (DEA), especially Charnes, Cooper and Rhodes (CCR) model and free disposal hull model to define the boundary of *H*.

2.1.1 Data envelopment analysis

DEA creates an "envelop" of observable production points [5]. DEA is based on linear programming techniques. It provides for flexible piecewise linear approximations to model the "best practice" reference technology. The output–based efficiency score is obtained from the following linear programming problem for each sub-industry.

$$\begin{aligned} &[D(x,y)]^{-1} = Max\theta_{it} \\ &subject\ \ to \\ &\theta_{it} y_{kit} \le \sum_{i=1}^{N} \lambda_{it} y_{kit}, \quad k = 1,2,...K \\ &\sum_{i=1}^{N} \lambda_{it} x_{jit} \le x_{jit}, \quad j = 1,2,...J \\ &\lambda_{it} \ge 0, \quad i = 1,2,...N, \quad t = 1,2,...T \end{aligned} \qquad (1)$$

θ is level technical efficiency and denoted by TE and the model is called the CCR model.

2.1.2 Free disposal hull models

The Free Disposal Hull (FDH) is first formulated by [6] and developed and extended by Tulkens and others. The basic motivation is to ensure that efficiency evaluations are affected only by observed performances. The FDH Frontier is obtained by replacing the last line in the model above, it means that the model can be as follows:

$$\begin{aligned} &[D(x,y)]^{-1} = Max\theta_{it} \\ &subject\ \ to \\ &\theta_{it} y_{kit} \le \sum_{i=1}^{N} \lambda_{it} y_{kit} \qquad k = 1,2,...K \\ &\sum_{i=1}^{N} \lambda_{it} x_{jit} \le x_{jit} \qquad j = 1,2,...J \\ &\sum_{i=1}^{N} \lambda_{it} = 1, \quad \lambda_{it} \in \{0,1\} \quad i = 1,2,...N; t = 1,2,...T \end{aligned} \qquad (2)$$

$\lambda_j \in \{0,1\}$ means that the components of λ are constrained to be bivalent. It can explain as: They must all have values of zero or unity so that $\sum_{i=1}^{N} \lambda_{it} = 1$, one and only one of the performance actually observed can be selected (see[8])

θ is level technical efficiency and denoted by TE and the model is called FDH model.

The efficiency results obtained from CCR and FDH models will be regressed on variables presenting channels of FDI's spillover effects on domestic firms in the second –stage regression..

2.1.3 Second –stage regression

To examine the impact of foreign presence on firms' efficiency, the efficiency results obtained from (1) and (2) are regressed on the variables capturing different aspects of foreign presence through some spillover channels. We estimate the following equation:

$$TE_{i,t} = \gamma_0 + \gamma_1 fs_{ij,t} + \gamma_5 hor_{j,t} + \gamma_2 back_{jt} + \gamma_3 forw_{j,t} + \gamma_4 sback_{j,t} + \alpha_t + \alpha_i + \varepsilon_{it} \qquad (3)$$

Wheresubscripts *i* and *t* refer to firm and time respectively. α_t capture time and α_i firm specific fixed effects. The above model is estimated using Ordinary Least Square Method (OLS) with time and fixed effects.

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

As in [7], *the variable Horizontal (* hor_{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,

$$hor_{j,t} = \frac{\sum_{j \in J} fs_{ij,t} * X_{ij,t}}{\sum_{j \in J} X_{ij,t}}$$

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:

$$back_{j,t} = \sum_{k\ if\ k \neq j} \gamma_{jk,t} hor_{k,t}$$

Where $\gamma_{jk,t}$ is the proportion of sector *j*'s output supplied to sourcing industry *k* at time *t* taken from the input-output tables 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.

The same way, we define the forward spillover variable $forw_{jt}$ as

$$forw_{j,t} = \sum_{l\ if\ l \neq j} \delta_{jl,t} hor_{l,t}$$

Where the Input - Output tables reveal the proportion δ_{jlt} of industry *j*'s inputs purchased from upstream industries *l*. Inputs purchased within the industry ($l \neq j$) are excluded, since this is captured by Horizontal.

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

$$sback_{j,t} = \sum_{i\ if\ l \neq j} \delta_{jl,t} back_{l,t}$$

Where $\delta_{jl,t}$ -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 $back_{j,t}$.

2.2 Efficiency Convergence among Firms

In this part, we present the models for testing unconditional convergence and conditional convergence.

2.2.1 Unconditional convergence

Empirical tests of convergence hypothesis (e.g., [3,9-14]), determine whether or not there is a closing of the gap between inefficient and efficient firms over time. One of approach is to regresses the log of firms' average growth rates in technical efficiency on the log of the firms' efficiency scores at the beginning of the sample period. The basic form of the equation of unconditional convergence is:

$$\frac{1}{T}[\ln TE_{i,final} - \ln TE_{i,initial}] = \alpha + \beta \ln TE_{i,initial} + \varepsilon_t \quad (4)$$

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 caching up is:

$$\lambda = 1 - (1 + \beta T)^{1/T}$$

2.2.2 Conditional convergence

To consider whether technical efficiency (from CCR and FDH models) 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 (*fs*), Horizontal (*hor*), Backward (*back*), Forward (*forw*) and supplybackward (*sback*) linkage measures into the model . The new equation of conditional convergence is:

$$\frac{1}{T}[\ln TE_{ij,final} - \ln TE_{ij,initial}] = \alpha + \beta \ln TE_{ij,initial} + \sum_{t=2000}^{2011} \delta_{1,t} fs_{j,t} + \sum_{t=2000}^{2011} \delta_{2,t} hor_{j,t} + \sum_{t=2000}^{2011} \delta_{3,t} back_{j,t} + \sum_{t=2000}^{2011} \delta_{4,t} forw_{j,t} + \sum_{t=2000}^{2011} \delta_{5,t} sback_{j,t} + \varepsilon_t \quad (5)$$

$$t = 2000, 2001, ..., 2011;\ j \in J = \{\mathrm{F, T;\ W;}WD\}$$

where subscripts *i,* and *t* refer to firm and time respectively.

3. RESULTS AND DISCUSSION

In this part, we discuss the results on a statistical base in order to see if FDI spillover effects on technical efficiency and estimate 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.

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 CCR and FDH models for the total sample, denoting CCRT and FDHT models, respectively and estimate efficiency using CCR and FDH models for sample of domestically owned firms, denoting CCRD and FDHD models, respectively.

3.2 Testing the Effects of FDI Spillovers on Firms' Technical Efficiency

Table 1 shows the results of estimating models (CCRT, FDHT, CCRD and FDHD models). A fixed-effects regression is used to assess the impact of the spillover effects of FDI on domestic firms' inefficiency. Technical efficiency measures from CCR and FDH models are regressed on *fs, hor, forw, back* and *sback*. Columns (2)-(3) show the results using the total sample. Columns (4)-(5) present the results using the sample of domestic firms. *Foreign share (fs)* bears a significant and positive sign (in CCRT models) but insignificant and negative sign (in FDHT models). *Hor* coefficients in two cases (FDHT and FDHD models) are positive and statistically significant at 1% and 5% level for the total sample of sub-industry and domestic firms, respectively. While *hor* coefficients in the rest of cases are negative and statistically significant at 5% level in the CCRT model but insignificant in the CCRD model. Positive and significant coefficients on *Back* are found for four models: CCRD, CCRT, FDHD and FDHT models. Backward spillovers go from the foreign firm to its upstream local suppliers. In these models, domestic firms draw apparently more benefits from their linkages to foreign firms. *forw* coefficients are statistically significant at least 10% level for all cases but they have the opposite sign. *Forw* coefficients are positive and statistically significant at 5% level in the cases of FDH models. *sback* coefficients are positive for all cases but *sback* coefficients of FDH models are insignificant. The results obtained from CCR models are similar to those in the literature. [7] estimates backward spillovers to be positive and forward spillovers to be negative but not statistically significant.

Table 1. Testing the effects of FDI spillovers on firms' technical efficiency

Fixed-effects regression				
Dependent variable	**TE from total sample of sub-industry sample**		**TE from domesticof sub-industry sample**	
	CCRT model	**FDHT model**	**CCRD model**	**FDHD model**
γ_0	0.029***	-0.005		
	(0.010)	(0.014)		
γ_1	-0.040**	0.053***	-0.020	0.048**
	(0.015)	(0.020)	(0.017)	(0.023)
γ_2	0.080***	0.095***	0.134***	0.091***
	(0.016)	(0.021)	(0.018)	(0.023)
γ_3	-0.086***	0.071**	-0.055*	0.095**
	(0.025)	(0.033)	(0.029)	(0.037)
γ_4	0.117***	0.041	0.085***	0.035
	(0.026)	(0.035)	(0.030)	(0.039)
_cons	0.127***	0.315***	0.123***	0.326***
	(0.005)	(0.007)	(0.006)	(0.008)
/sigma_u	0.144	0.242	0.145	0.236
/sigma_e	0.150	0.201	0.158	0.207
Rho	0.479	0.591	0.459	0.565

*Note: 1) standard errors are given in the parenthesis; 2) */**/*** Denotes significant at the 10, 5 and 1 percent levels, respectively*

Two models used here to measure the foreign spillover effects on firms' technical efficiency for the total sample of sub-industry and domestically owned firms of this sub-industry are based on nonparametric data envelopment analysis in the forms of CCR and FDH models. The impacts of foreign presence on firms' technical efficiency through *hor*, *back*, *forw* and *sback* variables are the same sign in CCRT, CCRD models (but difference in magnitude). To explain the differences in effects of FDI on firms' technical efficiency derived from the CCR and FDH models is that the set of constraints of CCR model is convex set, while the set of constraints of FDH model is not convex[6], since FDH model imposes one fewer restrictions on the data. Thus technical efficiency from FDH model is relative to an observed point on the frontier.

3.3 Estimated Results of Unconditional Convergence

Table 2 displays the cross-sectional OLS estimates of unconditional convergence for the total sample of sub-industry and the sample of domestically owned firms in Vietnamese manufacturing industry (theoretical model 4 in section 2.2).

The coefficients of initial technical efficiency from models 4.1T, 4.2T, 4.1D and 4.2D are -0.0769, -0.0627, -0.0798, -0.0644, respectively and significantly different from zero at 1%, confirming the presence of unconditional convergence during the period of 2000-2011. The speed of convergence of those model are 15.63%, 10.09%, 17.39%, 10.59%, respectively.

3.4 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 3 presents the cross-sectional OLS estimates of conditional convergence for the total sample of sub-industries and the sample of domestic firms. We estimate 4 models for the total sample of sub-industry and sample of domestic firms. 60 variables conditioning in these models are hor_{2000}, hor_{2001},…,hor_{2011}, $forw_{2000}$,…, $forw_{2011}$…variables.

Table 2. Unconditional convergence (2000-2011)

Dependent variable: The average year to year growth in the technical efficiency scores		**Speed of catching up**	**Half-line**
(a) Total sample of sub-industry			
Model 4.1T (TE from CCR model)	$\Delta \text{LnCCR}_{i,2011} = -\underset{(0.0091)}{0.2217}^{***} - \underset{(3.61E-06)}{0.0769}^{***} \text{LnCCR}_{i,2000}$ $R^2 = 0.43; DW = 1.79;$ Number of Observations $= 1038$	15.63%	8.66
Model 4.2 T (TE from FDH model)	$\Delta \text{LnFDH}_{i,2011} = \underset{(0.0043)}{-0.0892}^{***} - \underset{(0.0022)}{0.0627}^{***} \text{LnFDH}_{i,2000}$ $R^2 = 0.44; DW = 1.83;$ Number of Observations $= 1038$	10.09%	10.7
(b) Domestically owned firms in the sub-industry			
Model 4.1D (TE from CCR)	$\Delta \text{LnCCR}_{i,2011} = \underset{(0.0097)}{-0.0234}^{***} - \underset{(0.0029)}{0.0798}^{***} \text{LnCCR}_{i,2000}$ $R^2 = 0.45; DW = 1.82;$ Number of Observations $= 907$	17.39%	8.33
Model 4.2D (TE from FDH)	$\Delta \text{LnFDH}_{i,2011} = \underset{(0.0043)}{-0.0895}^{***} - \underset{(0.0023)}{0.0644} - \text{LnFDH}_{i,2000}$ $R^2 = 0.46; DW = 1.71;$ Number of Observations $= 907$	10.59%	10.41

*Note: 1) standard errors are given in the parenthesis;2) */**/*** Denotes significant at the 10, 5 and 1 percent levels, respectively, 3) Model 4.1T is model 4 in section 2.2, where TE estimated from CCR model and estimated using total sample; Model 4.2T is model 4 in section 2.2, where TE estimated from FDH model and estimated using total sample; Model 4.1D is model 4 in section 2.2, where TE estimated from CCR model and estimated using sample of domestic firms; Model 4.2D is model 4 in section 2.2, where TE estimated from FDH model and estimated using sample of domestic firms*

Table 3. Conditional convergence (2000-2011)

(a) For total sample of sub-industry with number of observations =1038

(5.1T)

$$\Delta \ln CCRT_{ij,2011} = -\underset{(0.0264)}{0.1532}^{***} - \underset{(0.0026)}{0.0836}^{***} LnCCRT_{ij,2000} - \underset{(0.4384)}{0.8835}^{**} back_{j,2000} + \underset{(0.0398)}{0.0896}^{**} hor_{j,2001}$$

$$+ \underset{(0.1034)}{0.2357}^{**} back_{j,2001} + \underset{(0.1370)}{0.3062}^{**} forw_{j,2001} - \underset{(0.1268)}{0.5397}^{***} sback_{j,2001} - \underset{(0.1238)}{0.4663}^{***} forw_{j,2001}$$

$$+ \underset{(0.0395)}{0.1024}^{***} hor_{j,2005} - \underset{(0.0453)}{0.1559}^{***} back_{j,2005} + \underset{(0.0145)}{0.025}^{***} fs_{j,2008} + \underset{(0.0306)}{0.055}^{***} back_{j,2009}$$

$$+ \underset{(0.0145)}{0.089}^{***} fs_{j,2010} + \underset{(0.014)}{0.135}^{***} forw_{j2011}$$

R^2=0.5 DW =1.92

Speed of catching up =22.92% ; Half-line= 7.94

(5.2T)

$$\Delta \ln FDHT_{ij,2011} = -\underset{(0.0083)}{0.2366}^{***} - \underset{(0.0083)}{0.0832}^{***} LnFDHT_{ij,2000} + \underset{(0.0083)}{0.4873} +{}^{***} sback_{j,2000} - \underset{(0.0099)}{0.021}^{***} hor_{j,2005}$$

$$+ \underset{(0.0089)}{0.017}^{*} back_{j,2008} + \underset{(0.009)}{0.028}^{*} back_{j,2009} - \underset{(0.0089)}{0.049}^{***} forw_{j,2009} - \underset{(0.0083)}{0.023}^{*} hor_{j,2011} - \underset{(0.0066)}{0.024}^{***} back_{j,2011}$$

$$+ \underset{(0.005)}{0.273}^{***} forw_{j,2011}$$

R^2=0.89; DW =1.86

Speed of catching up =22.43% ; Half-line= 7.98

(b) For domestically owned firms of sub-industry with number of observations: 907

(5.1D)

$$\Delta \ln CCRD_{ij,2011} = \underset{(0.0343)}{-0.1151}^{***} - \underset{(0.0028)}{0.0823}^{***} LnCCRD_{ij,2000} + \underset{(0.1043)}{0.2398}^{**} back_{j,2000} + \underset{(0.0376)}{0.089}^{**} hor_{j,2000}$$

$$+ \underset{(0.1712)}{0.4011}^{**} forw_{j,2000} + \underset{(0.1764)}{0.4507}^{**} sback_{j,2000} - \underset{(0.4268)}{1.0611} back_{j,2000}^{***} - \underset{(0.0976)}{0.2823}^{***} forw_{j,2004}$$

$$- \underset{(0.0511)}{0.1515}^{***} back_{j,2006} + \underset{(0.0473)}{0.1026} {}^{**}hor_{j,2006} - \underset{(0.1712)}{0.2066}^{*} forw_{j,2007} + \underset{(0.0321)}{0.0616}^{**} back_{j,2011}$$

R^2=0.52; DW =1.92

Speed of catching up =21.42%;Half-line= 8.07

(5.2D)

$$\Delta \ln FDHD_{ij,2011} = -\underset{(0.0083)}{0.0813}^{***} - \underset{(0.0027)}{0.0755}^{***} LnFDHD_{ij,2000} + \underset{(0.0300)}{0.1448}^{**} back_{j,2000} + \underset{(0.1043)}{0.0706}^{***} hor_{j,2001}$$

$$- \underset{(0.0888)}{0.2195}^{***} back_{j,2003} - \underset{(0.0513)}{0.0875}^{***} forw_{j,2003} + \underset{(0.0209)}{0.738}^{***} back_{j,2009} - \underset{(0.0475)}{0.2527}^{***} sback_{j,2010}$$

$$+ \underset{(0.0198)}{0.0848}^{***} back_{j,2011} - \underset{(0.0216)}{0.0966}^{***} hori_{j,2011} + \underset{(0.0449)}{0.0944}^{**} forw_{j,2011}$$

R^2=0.52; DW =1.79

Speed of catching up =16.13% ; Half-line= 8.83

*Note: 1) standard errors are given in the parenthesis; 2) */**/*** Denotes significant at the 10, 5 and 1 percent levels, respectively, 3) Model 5.1T is model 5 in section 2.2, where TE estimated from CCR model and estimated using total sample; Model 5.2T is model 4 in section 2.2, where TE estimated from FDH model and estimated using total sample; Model 5.1D is model 4 in section 2.2, where TE estimated from CCR model and estimated using sample of domestic firms; Model 5.2D is model 4 in section 2.2, where TE estimated from FDH model and estimated using sample of domestic firms*

3.4.1 Comparing the speed of convergence from unconditional convergence models

Table 4 displays the results of comparing the speed of unconditional convergence models and conditional convergence models. Columns 2, 3, 4, 5 report the results of speed of convergence and half-line of unconditional models. Columns 6, 7, 8, 9 present the results of speed of convergence and half-line of conditional models. The results show that the speed of conditional convergence models through channels of FDI effects must be faster than those from unconditional convergence models.

Table 4. Comparing the speed of convergence from unconditional convergence models and conditional convergence models

	Unconditional convergence models				**conditional convergence models (Impact of FDI on speed of convergence)**			
	TE from total sample		**TE from sample of domestic firms**		**TE from total sample**		**TE from sample of domestic firms**	
	Model 4.1T	Model 4.2T	Model 4.1D	Model 4.2D	Model 5.1T	Model 5.2T	Model 5.1D	Model 5.2D
Speed of convergence	15.63 %	10,09%	17,39%	10,59	22,92%	22,43%	21,42%	16,14%
Half line	8.66	10,7	8,33	10,41	7.94	7.98	8.07	8.83

4. CONCLUSION

This study analyzed horizontal and vertical productivity spillovers of foreign direct investment on technical efficiency convergence in Vietnamese sub-industries from 2000 to 2011. Dynamic I-O tables (2000 and 2005) were used to construct the linkages between domestic and foreign firms and to set out the model in which several channels through which FDI could affect efficiency and efficiency convergence of the domestically owned firms . Using a panel dataset covering sub-industries in Vietnamese manufacturing firms from 2000 to 2011.

We found the existence and the nature of the effect of FDI on firms' efficiency and efficiency convergence at firms levels in the sub-industries: (1) there were impact of FDI on domestic firms' efficiency score and convergence at a firm level; (2) the presence of FDI increased the speed of efficiency convergence in domestically owned firms.

ACKNOWLEDGEMENTS

Funding from Vietnam National Foundation for Science and Technology Department (NAFOSTED), under grant number II 2.2-2012.18 is gratefully acknowledged. We would like to send special thank to researchers who commented on our paper at the 12th International Conference on Data Envelopment Analysis (DEA2014) in Malaysia on 14-17 April 2014.This manuscript has also benefited from comments by the editor and two anonymous referees.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Dorwick S, Nguyen DT. OECD Comparative Economic Growth 1950-85: Catch-Up and Convergence. American Economic Review. 1989;79(5):1010–1031.
2. Bernard AB, Jones CI. Comparing Apples to Oranges: Productivity Convergence and Measurement Across Industries and Countries. American Economic Review. 1986;86 (5):1216–1239.
3. Alam IMS, Sickles RC. Time Series Analysis of Deregulatory Dynamics and Technical Efficiency: The Case of the U.S. Airline Industry. International Economic Review. 2000;41(1):203-218.
4. Farrell MJ. The measurement of Productive Efficiency. Journal of the Royal Statistical Society. 1957;120:253-281.
5. Charnes A, Cooper WW, Rhodes E. Measuring the efficiency of decision-making units. European Journal of Operational Research. 1978;2(6):429-444.
6. Deprins D, Simar L, Tulkens H. Measuring Labor-Efficiency in Post Offices. In: Marchand M, Pestieau P, Tulkens H, editors. The Performance of Public Enterprises: Concepts and Measurement. Amsterdam: North Holland; 1984.
7. Javorcik BS. Does foreign direct investment increase the productivity of domestic firms? In search of spillovers through backward linkages. American Economic Review. 2004;94(3):605-627.
8. Bardhan I, Bowlin WF, Cooper WW, Sueyoshi, T. Models and Measures for

Efficiency Dominance in DEA. Journal of Operations Research Society of Japan. 1996;39:322-332.
9. Barro RJ. Economic growth in a cross section of countries. Quarterly Journal of Economics. 1991;106:407-443.
10. Barro RJ, Sala-i-Martin X. Economic Growth. McGraw Hill, New York; 1995.
11. Baumol WJ. Productivity Growth, Convergence and Welfare: What the Long Run Data Show. American Economic Review 76. 1986;1072-1085.
12. De Long JB. Productivity Growth, Convergence, and Welfare: Comment. American Economic Review. 1988;78:1138-1154.
13. Islam N. Growth Empirics: A panel data approach. Quarterly Journal of Economics. 1995;110:1127-1170.
14. MankiwNG, Romer D, Weil DN. A contribution to the empirics of economic growth. Quarterly Journal of Economics. 1992;107:407-437.
15. Blomstrom M, Kokko A. Multinational Corporation and Spillovers. Journal of Economic Survey. 1998;12(2):247-277.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=686&id=20&aid=6255