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Effects of FDI on efficiency convergence in manufacturing of machinery industry

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Abstract

The aim of this paper is to analyze the spillover effects of FDI on domestically owned firms' efficiency and efficiency convergence in manufacture of machinery industry in Vietnam. Methodologically, we approach this question in two steps. In the first step, we estimate firms' efficiency by using CCR model and test the effects of FDI spillovers on firms' efficiency. In the second step, we test efficiency convergence and identify the impact of FDI spillover effects through the horizontal and vertical channels on efficiency convergence. Consistent with the findings of the previous studies, we find negative evidence of significant horizontal spillover effects. In contrast, we find no evidence of significant vertical spillover effects on domestic firms' efficiency. The net effect of FDI spillovers on efficiency convergence at firms' level is negative.

Keywords, Machinery industry, Efficiency, Spillover effect, Horizontal and Vertical channels, Convergence

I. Introduction

According to Vietnam Industrial Investment Report 2011, in recent year, economic growth in Vietnam has been mainly driven by the expansion of trade and investment, including foreign direct investment (FDI).

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During the period 1988 to 2010, the annual rates of growth of registered FDI came to a staggering 34 per cent, greatly outweighing the growth rates of other developing country recipients of FDI.

The sectoral composition of FDI is mainly concentrated in manufacturing industry. Manufacturing alone accounts for the largest share of the number of FDI projects (58.0 per cent of the total) and this volume highlights some potential for intra and inter-sectoral spillovers.

This paper, by using firm-level data set in manufacture of machinery industry in Vietnamese manufacturing industry, investigates the existence and magnitude of technology spillovers from foreign to domestic firms. Moreover, the paper examines whether efficiency convergence process occurred in the presence of FDI through horizontal and vertical spillovers at firm level.

At the firm level, the empirical studies provide mixed evidence of the spillover effect on the local firms. Most empirical studies focus on horizontal (intra-industry) spillovers and find no or negative effects of FDI on the efficiency of domestic firms (Haddad and Harrison (1993), Aitken and Harrison (1999), Konings (2001), Yudaeva *et al*. (2003)). Several studies, particularly on vertical (inter-industry) spillovers, provide positive evidence of technology spillovers from foreign to domestic firms (Blalock and Gertler (2002), Schoors and Van der Tol (2002), Smarzynska (2004)).

Productivity convergence has received attention both at the country level (Dollar and Wolff (1988), Dorwick and Nguyen (1989), Wolff (1991)) and at the industry level (Baumol (1986), Bernard and Jones (1996), Pascual and Westermann (2002)). However, there has been little empirical work at the firm level on efficiency convergence (Alam and Sickles (2000). Nguyen Khac Minh *et al.* (2014) focus on the horizontal and vertical effects of FDI on efficiency and efficiency convergence in food products and beverages; textile; wearing apparel; footwear and manufacture of wood and products of wood. They find evidence of positive spillovers from FDI on domestic firms' efficiency and efficiency convergence.

In this paper, firms' efficiency is estimated by using CCR (Charnes, Cooper and Rhodes (1978)). Next, to examine spillover effects, we take regression of the efficiency results on the variables capturing different aspects of foreign presence.

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

We apply this methodology to the total sample of machinery industry in Vietnamese manufacturing industry (manufacture of machinery industry includes (1) Manufacture of Radio (R), television and communication equipment and apparatus (T); (2) Manufacture of Medical precision and optical (M) (3) Manufacture of motor vehicles (MV), trailers and semi-trailers (TS), and (5) manufacture of other transport equipment (TE).

This paper contains four sections as follows. The next section presents methodology. Section 3 describes the data and the estimation. The final section presents conclusions.

II. Methodology

2.1 Efficiency Measurement

The production technology S^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:

$$S^t = \left\{(x_t, y_t) : x_t \; can \; produce \; y_t\right\},$$

Where S^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 be defined as:

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

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 Farrell's (1957) 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).

2.1.1. Data Envelopment Analysis

DEA creates an "envelop" of observable production point (Charnes, Cooper and Rhodes (1978)). DEA is based on linear programming techniques.

Assume that there are i=1,2,…N firms , t=1,2,…T periods, j=1,2,3,…J inputs , and k=1,2,…K outputs in manufacture of machinery industry .

The output–based efficiency score is obtained from the following linear programming problem for each sample (total sample and sample of domestic firms) (CCR model).

$$[D(x,y)]^{-1} = Max\theta_{it}$$

$$subject\ \ to$$

$$\sum_{i=1}^{N} z_{it} y_{kit} - \theta_{it} y_{kit} \geq 0 \quad k = 1,2,...K$$

$$x_{jit} - \sum_{i=1}^{N} z_{it} x_{jit} \geq o, \quad j = 1,2,...J$$

$$z \geq 0.$$

θ is level efficiency. θ_T, θ_D are efficiency, estimated by using total sample and sample of domestic firms, respectively.

2.2. Second –Stage Regression

To examine the impact of foreign presence on firms' efficiency, the efficiency results obtained from CCR model are regressed on the variables capturing different aspects of foreign presence. Following Nguyen Khac Minh *et al.* (2014), we estimate the following equation:

$$\theta_{it} = \gamma_0 + \gamma_1 sf_{ijt} + \gamma_5 hori_{jt} + \gamma_2 Back_{jt} + \gamma_3 Forw_{jt} + \gamma_4 Sback_{jt} + \alpha_t + \alpha_i + \varepsilon_{it} \quad (2)$$

Where subscripts *i* and t refer to firm and time respectively. α_t and α_i capture time and firm specific effects respectively. We create five spillover variables sf, hori, back, forw, sback:

Horizontal ($Hori_j^t$) 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. It can be defined as:

$$Hori_{jt} = \frac{\sum_{j \in J} sf_{ij\,t} * X_{ijt}}{\sum_{j \in J} X_{ijt}}$$

where 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 defined in the following way: $Back_{jt} = \sum_{k\ if\ k \neq j} \gamma_{jkt} Hori_{kt}$

where γ_{jkt} is 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. Since firms cannot easily switch among industries their inputs, to avoid the problem of endogeneity, we use the share of industry output sold to downstream domestic market k with some level of foreign $Hori_{jt}$.

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 I-O tables reveal the proportion δ_{jlt} of industry j's inputs purchased from upstream industries l. Input purchased within the industry ($l \neq j$).

Thus the greater the foreign presence in sectors supplied by are also excluded, since this is captured by Horizontal.

Supplybackward (denoted by $Back_{lt}$*)* 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} is proportion of industry j's inputs purchased from upstream industries l that in turn supply the downstream industries of foreign firms as measured by variable $Back_{jt}$.

The above model is estimated using Ordinary Least Square Method (OLS) with time and fixed effects[4].

2.3. Efficiency Convergence Among Firms

2.3.1. Unconditional Convergence

Following Alam and Sickles (2000), Nguyen Khac Minh *et al.* (2014), we take regression of average growth rates on a constant and the initial efficiency levels. The basic form of the equation of unconditional convergence is
:

$$\frac{1}{T}[\ln \theta_{i,\,final} - \ln \theta_{i,initial}] = \alpha + \beta \ln \theta_{i.initial} + \varepsilon_t , \qquad (3)$$

Where T is number of years considered; θ is 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: $\lambda = 1 - (1 + \beta T)^{1/T}$.

2.3.2. Conditional Convergence

Since it may take more time before FDI's spillovers effects on domestic firms' efficiency, to consider whether efficiency convergence occurring in the presence of FDI through spillovers to domestic firms, we include lagged foreign share (Sf), Horizontal (Hori) Backward (Back) and Forward (Forw) and supplybackward (Sback) linkage measures into the model .

Following Nguyen Khac Minh *et al.* (2014), the new equation of conditional convergence is:

$$\frac{1}{T}[\ln\theta_{i,final} - \ln\theta_{i,initial}] = \alpha + \beta \ln\theta_{i.initial} + \sum_{t=2000}^{2011} \delta_{jt}^{(0)} Hori_{jt} + \sum_{t=2000}^{2011} \delta_{jt}^{(1)} Hori_{jt}$$
$$+ \sum_{t=2000}^{2011} \delta_{jt}^{(2)} Back_{jt} + \sum_{t=2000}^{2011} \delta_{jt}^{(3)} Forw_{jt} + \sum_{t=2000}^{2011} \delta_{jt}^{(4)} Sback_{jt} + \varepsilon_t \quad (4)$$
$$t = 2000, 2001, ..., 2011; i, j \in J = \{(\text{R, T, M, MV, TS and TE})\}$$

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 efficiency convergence in this industry. Then the key variables in the unconditional convergence model are the foreign share (sf) Horizontal (Hori), forward (Forw), backward (Back) and supply backward 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 (GSO) over the 2000-2011 periods. Industry data is available at a 4-digit level. We dropped 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 incomplete. We select firms being survivors that continue to stay in the market between year 2000 and year 2011. The number of firms in our sample of sub-industry is 95 observations and the sample of domestic firms is 52 observations for each year.

3.3. Testing the Effects of FDI Spillovers on Firms' Efficiency in Manufacture of Machinery

Table 1a: Fixed Effect Regression from the Total Sample

θ_T	Sf	Hori	Back	Forw	Sback	_Cons	/sigma_u	/sigma_e	Rho
	0.075 (0.049)	-1.101* (0.054)	-0.223 (0.235)	0.131 (0.284)	0.127 (0.14)	0.339*** (0.033)	0.209	0.227	0.489

Table 1b: Fixed Effect Regression from the Domestic Sample

θ_D	Hori	Back	Forw	Back	_Cons	/sigma_u	/sigma_e	Rho
	-0.267*** (0.083)	-0.274 (0.412)	0.617 (0.	0.184 (0.132)	0.492*** (0.055)	0.210	0.257	0.43 9

1) Standard errors are given in the parenthesis; 2) ***/**/* Denotes significant at α=0.01; α=0.05 and α=0.10, respectively.

The estimation results in the table 1 provide some suggestions as follows:

The coefficient of sf variable in total sample model is positive but not statistically significant.

The coefficient of Hori (horizontal spillover) (spillover from a foreign company to a domestic one in the same industry) is negative and highly statistically significant in two models. There are two main channels for the horizontal spillover: the mobility of trained workers from foreign firms and demonstration effect. The entry of foreign firms also stirs the competition in the domestic market. More drastic competition urges domestic firms to use the existing technologies and resources more efficiently or to adapt to new technologies and organizational habits. However, no impact of these effects necessarily is positive. The negative coefficient of Hori variable and high statistical significance may be due to the negative spillovers of labor market such as brain drain - the shift of talent staff from domestic firms to the foreign ones - harming efficiency of domestic firms or the raise in overall wage level without considering the improvement of efficiency caused by foreign firms' higher wage paying (Aitken *et al.*, 1996).

The policies definitely restrict the horizontal spillovers through the demonstration effect. Higher efficiency of foreign branches may also lead to lower prices or less demand for the products of domestic competitors. If domestic firms do not adapt to increasing competition and increase their efficiency, they will be forced to stand above the average cost curve. The efficiency of domestic manufacturers is reduced due to the synthesis impact of these negative effects. Consequently, it results in the fact that many domestic firms not only be left behind but also pushed out of business because of the shock caused by the entry of foreign ones.

The coefficients of Back variable (denoting the backward spillovers from foreign firms to local upstream suppliers) are not statistically significant in both models. This may be due to that fact that foreign firms attempt to minimize the leakage of its technology to direct competitors or domestic firms do not have ability to absorb advanced technology. Another reason is that due to the low quality of local input, foreign firms decide to purchase inputs from other countries, so that there is no technology transfer or limited technology transfer. In such conditions, backward spillovers can be harmful however not significant.

The coefficient of forw variable (forward spillover from foreign firms to local downstream buyer) is positive and not statistically significant. This may be due to the fact that the availability of better inputs caused by foreign investment increases the efficiency of firms using these inputs. However, it is inexplicit.

The coefficient of Sback variable (supplybackward spillover from foreign firms through their local suppliers to local customers of these suppliers) is positive but not statistically significant in both models.

3.5. Banker's Asymptotic DEA Efficiency Tests

Two Banker's asymptotic DEA efficiency tests have been used to test for inefficiency differences between two different efficiency scores. Firstly, we assume that the two inefficiencies ($1-\theta_T$ and $1-\theta_D$) follow the exponential distribution.

The test statistic is

$\frac{\sum_i (1-\theta_{Ti}) / N_T}{\sum_l (1-\theta_{Dl}) / N_D}$, estimated relative to the F distribution with ($2N_T$, $2N_D$) degrees of freedom. Secondly, we assume that two inefficiencies ($1-\theta_T$ and $1-\theta_D$) follow the half-normal distribution. The test statistic is

$\frac{\sum_i (1-\theta_{Ti})^2 / N_T}{\sum_l (1-\theta_{Dl})^2 / N_D}$, estimated relative to the F distribution with (N_T, N_D) degrees of freedom. Where TE is the efficiency and N is the sample's size.

Table 2: Summary of Efficiency Difference Test Results for Total Sample and Domestically Owned Firms

Year	Total sample vs Domestic firms	Total sample vs Domestic firms	Critical value		
	Exponential type	Half-normal type	1%	5%	10%
	θ_T vs θ_D	θ_T^2 vs θ_D^2			
2000	1.460*	1.710**	1.820	1.520	1.380
2001	1.171	1.208	1.820	1.520	1.380
2002	1.151	1.142	1.820	1.520	1.380
2003	1.059	1.057	1.820	1.520	1.380
2004	1.168	1.206	1.820	1.520	1.380
2005	1.270	1.386*	1.820	1.520	1.380
2006	1.238	1.309	1.820	1.520	1.380
2007	1.328	1.534**	1.820	1.520	1.380
2008	1.439	1.727	1.820	1.520	1.380
2009	1.342*	1.503	1.820	1.520	1.380
2010	1.226	1.327	1.820	1.520	1.380
2011	1.145	1.251	1.820	1.520	1.380

*Note ***/**/* represents significant at 0.01, 0.05 and 0.1 level, respectively.*

The results of Banker's asymptotic DEA efficiency tests are reported in table 3.

Banker test under the assumption that the inefficiency follows exponential distribution is shown in 2th column.

The values of the F-statistic are calculated under the assumption θ_T and θ_D estimated from the same DEA model but using two different samples. The results show that in total of 12 test values (corresponding to 12 years), there are only two values (2000 and 2009) being greater than the critical value at the 10 % significance level.

Banker test under the assumption that the inefficiency follows the half-normal distribution is shown in 3th column. The values of the F-statistic are calculated under the assumption θ_T and θ_D estimated from the same DEA model but using two different samples. The results show that there are only three test statistics (2000, 2005 and 2007) being significant.

Such tests indicate that the efficiencies estimated from total sample data (both domestic and foreign firms) and from the sample consisting domestic firms only are not much different.

3. 5. Convergence Results

3.5.1. Estimated Results of Unconditional Convergence

The estimated results of 2 unconditional convergence models are presented in Table 3.

The coefficient of initial efficiency is negative and statistically significant in the two models. It implies the conclusion that there is efficiency convergence in this sub-industry is unchangeable whether to use the sample including both foreign firms and domestic firms or the sample including domestic firms only. However, the convergence speed may vary. Efficiency convergence rate estimated from CCR model for the total sample is 9.61 %, more than 4.3 times faster than the rate estimated for the sample consisting domestic firms only (2.23%).

Table 3: Unconditional Convergence (2000-2011)

Dependent variable: The average year to year growth in the efficiency scores

	(a) Total sample of sub-industry	Speed of catching up	Year
(1)	$DLnq_{i,2011} = \underset{(0.023)}{-0.112}*** \underset{(0.012)}{-0.061}***Lnq_i^{2000}$; $R^2 = 0.212; DW = 1.48;$ Number of Observations = 95	9.61%	11.01
	(b) Domestically owned firms in the sub-industry	Speed of catching up	Year
(2)	$DLnq_{i,2011} = \underset{(0.0056)}{-0.029}*** \underset{(0.004)}{-0.020}***Lnq_{i,2000}$; $R^2 = 0.29; DW = 1.87;$ Number of Observations = 52	2.23%	34.3

Note: 1) standard errors are given in the parenthesis; 2) *** Denotes significant at the 1 percent level.

3.5.2. Estimated results of conditional convergence

The estimated results of efficiency convergence from the total sample (both domestic firms and foreign firms) and the sample including domestic firms in manufacture of machinery industry show that:

(1) In case of using the sample consisting both domestic and foreign firms in manufacture of machinery industry - model (3), the convergence rate is 7.2 %. There are only 3 out of all variables denoting the impact of FDI to efficiency in the past 12 years being statistically significant. Sf variable denoting the effect of the presence of FDI in 2000 to the efficiency convergence model of domestic firms is positive and statistically significant. Hori variable denoting horizontal spillover effects of FDI in 2000 to the efficiency convergence model of domestic firms is also positive and statistically significant. Nevertheless, Back variable denoting reverse spillover effects of FDI in 2004 to the efficiency convergence model is negative and statistically significant. The total effect of these three variables is negative. It may be the reason why the convergence speed of this model (7.2 %) is slower than unconditional convergence model's (1) in Table 3 (9.61 %).

(2) In case of using the sample including domestic firms in manufacture of machinery industry only - model (4), the convergence rate is 2.6 %.

Convergence speed of this model is much slower than the convergence speed estimated from total sample (including both foreign and domestic firms).

Table 4: Conditional Convergence (2000-2011)

	(a) For total sample of sub-industry with number of observations =95	
(3)	$\Delta \ln \theta_{i,2011} = \underset{(0.032)}{-0.199^{***}} \underset{(0.011)}{-0.051^{***}} Ln\theta_{i,2000} + \underset{(0.029)}{0.098^{**}} SF_{j,2000}$ $+ \underset{(0.065)}{0.188^{**}} Hori_{j,2000} - \underset{(0.199)}{0.333^{*}} Back_{j,2004}$ $R^2 = 0.43; DW = 2.02; \text{Number of Observations} = 95$	R^2=0.5 DW =1.92 Speed of catching up=7.2% Half-line=13.24
	(b) For domestically owned firms of sub-industry with number of observations : 52	
(4)	$\Delta \ln \theta_{i,2011} = \underset{(0.027)}{-0.103^{***}} \underset{(0.005)}{-0.023^{***}} Ln\theta_{i,2000} + \underset{(0.036)}{0.098^{*}} Hori_{j,2005}$ $\underset{(0.055)}{-0.175^{**}} Hori_{j,2006} + \underset{(0.196)}{0.521^{**}} Forw_{j,2000} + \underset{(0.101)}{0.255^{**}} Hori_{j,2010} \underset{(0.088)}{-0.185^{**}} Hori_{2011}$ $R^2 = 0.49; DW = 1.79; \text{Number of Observations} = 52$	R^2=0.52; DW =1.92 Speed of catching up=2.6% Half-line =29.79

*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 examines technology spillover from FDI to domestic firms and its effect on efficiency and efficiency convergence in manufacture of machinery industry of Vietnamese manufacturing industry from 2000 to 2011. Using a panel dataset covering firms in Vietnamese manufacture of machinery from 2000 to 2011, we found that (1) the horizontal spillover effect from FDI to domestic firms' efficiency is negative; however there is no evidence of vertical spillover effect; (2) the net effects from FDI on Efficiency convergence in Vietnamese manufacture of machinery industry is negative.

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