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The Effect of Technology Spillover on Business Efficiency: A Case Study in Vietnam

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Abstract

The main objective of this study is to examine the interactive effect of technology spillover channels on business efficiency within the case study of manufacturing industry of Vietnam during the period from 2012 to 2018. The research model was developed with business efficiency as dependent variable and the relevant factors affecting the technology spillover capacity as independent variables. With a sample of 2,776 cross-sectional enterprises, panel data analysis approach was adopted to estimate the impact of technology spillover issue. Different spillover channels were also included in the analysis to enhance the empirical result. The study reveals that technology spillovers positively influence manufacturing business efficiency, in which horizontal spillover channel produces negative impact and vertical spillover channel, creates positive impact. Several factors that negatively affect the technology spillover capacity of businesses could be mentioned such as limited skills and experiences of workers, methods of implementing R&D, and the existence of FDI enterprises. Meanwhile, the rise of other factors related to joint-venture activities can help to increase the technology spillover capacity of businesses. In addition, skill and experience transfer makes a partial impact since this variable only positively affect the vertical spillover channel and provide no evidence of impact regarding horizontal spillover channel model.

Keywords: Technology Spillover, R&D, Technology Innovation, Manufacturing Industry

JEL Classification Code: L60, O30, O32

1. Introduction

Solow (1956, 1957) is one of the first scholars to underline the critical importance of technology innovation in "leveraging" long-term national economic growth. However, technological research and renovation activities are mostly carried out by large multinational enterprises or governments of the largest economies in the world. After that, these innovative technologies will spillover to the rest of the world via a number of channels such as international commerce of machinery equipment, emigration, foreign direct investment (FDI), transferring of patents for invention, etc. Therefore, investment in technology, not only benefits investors, but also contributes to other businesses. This is known as technology spillover (Romer, 1990). Technology spillover is an opportunity for low-tech enterprises to improve their technology level and catch up with high-tech enterprises through a step-by-step process including learning, imitating, and transferring technology, and thereby improving performance efficiency. Most of theoretical and empirical

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studies examining the impact of technology spillover have shown that technology spillover has a significant impact on enterprise productivity and output (Nguyen, Nguyen, & Tran, 2014; Guo, 2007; Medda & Piga, 2014).

2. Literature Review

The foreign direct investment (FDI) sector has always been a major sector that contributed largely to the economic growth of Vietnam since economic reform event in 1986 (Ta, Le, Nguyen, Phan, & Do, 2020). With the advantage of a fast-growing economy and considerably cheap labor cost, Vietnam has become an attractive destination of FDI companies (Do, Nguyen, Le, & Ta, 2020). One of the most important outcomes that developing governments expected from attracting FDI enterprises is technology transfer, also known as technology spillover. Hence, most studies often focus on the technology spillover made by FDI firms to affect the productivity and output of host country's local firms (Hoang, Do, & Trinh, 2020; Hoang & Pham, 2010; Keller & Yeaple, 2009; Liu, Wang, & Wei, 2009; Salim & Bloch, 2009; Schoors & Merlevede, 2007; Suyanto & Nguyen, 2009; Tran, 2011). In fact, not all FDI enterprises create technology spillover and technology spillover is created not only from FDI enterprises, but also from domestic enterprises with different types of ownership. It is worth noting that studies on the effects of technology spillover of domestic firms have not been exploited much in the literature. Several studies have found a positive effect of technology spillover on firm output productivity (Antonelli, 1994; Hassan, Ahsan, Danial, Wajiha, & Zahoor, 2011; Nishimura, Nakajima, & Kyyota, 2005; Medda & Piga, 2014; Nguyen, Nguyen, & Tran, 2014), while a few studies showed negative or no effect of the technology spillover variables (Klette, 1994; Czarnitzki & Kraft, 2012).

To identify enterprises with higher level of technology that are capable of creating technology spillover to lower-level technology enterprises is challenging as most studies often identify high-tech enterprises as the ones with the highest level of aggregate productivity factor at any given time in each industry or based on the overall marginal production curve (Worthington & Lee, 2008; Glass & Saagi, 1998; Schoors & Merlevede; 2007, Nguyen, Nguyen, & Tran, 2014; O'Donnel, Rao, & Battese, 2008). However, technology spillover may come from enterprises importing modern foreign technological machinery.

Some studies have initially investigated the effects of several factors on technology spillover and showed that the existence, direction, and magnitude of the spillover effects can be influenced by many factors that indirectly affect business productivity and efficiency variables such as firm size, R&D activities, operational incentives for R&D, market share, type of ownership, and other institutional factors (Griliches, 1957; Hoang, Do, & Trinh, 2020; Mansfield, 1968). In addition, several factors such as firm's ability to absorb and assimilate technology, technological level, R&D activities or supply chain relationship between supplier and customer impact spillover intensity (Kitson, 2001; Cohen & Levinthal, 1989; Watanabe, 2001; Bonte, 2008; Fu & Gong, 2009; Kenta, Rene, Fukao, Young, & Kwon, 2015). The variables that are included into the regression model are often in the form of variables that have interaction with technology spillover variables, but they are still relatively fragmentary. Particularly in Vietnam, there is no research that analyzes the interactive effect of each technology spillover channel on enterprise efficiency. This makes it difficult for decision-makers to formulate scientifically-sound policy to promote the relevant factors that provide positive effects and minimize the factors that negatively affect the spillover channels and business efficiency. Therefore, this study focuses on answering important questions including whether technology spillovers affect business performance, and if so, what factors can actually increase the technology spillover effect on different channels, as well as what factors create barriers or inhibit spillover effects, thereby proposing relevant recommendations.

3. Research Methodology

3.1. Random Marginal Production Function Model to Identify Business Efficiency

The concept of technical efficiency (TE) used in this study is represented by the ability to maximize input savings to produce a given amount of output or, in other words, the ability to produce a maximum amount of output from a given amount of input, corresponding to a certain level of technology (Farell, 1957).

This study uses Battese and Coelli's (1995) transcendental logarithmic production function to measure efficiency as follows:

$$\begin{aligned} \text{In } VA_{it} &= \alpha_0 + \beta_K \text{In } K_{it} + \beta_L \text{In } L_{it} + \beta_T T_{it} + \beta_{KK} (\text{In } K_{it})^2 \\ &+ \beta_{LL} (\text{In } L_{it})^2 + \beta_{TT} T_{it}^2 + \beta_{KL} (\text{In } K_{it})(\text{In } L_{it}) \\ &+ \beta_{TK} T_{it} L_{it} nK + \beta_{TL} T_{it} \text{ In } L_{it} + \upsilon_{it} - \mu_{it} \end{aligned} \quad (1)$$

Where T is the time to denote technological progress; VA_{it}, K_{it} and L_{it} are value added, capital and labor of firm i in year t; v_{it} is a random error; μ_{it} is a non-negative random variable representing the effects of technical inefficiencies $N(\mu_{it,} \sigma_u^{\ 2})$.

In order to select a suitable model for the research dataset, the one-sided generalized reasonable ratio test method was used with the test statistic as follows:

$$\mathrm{LR}(\text{or } \lambda) = 2\{[L(H_0)] - [L(H_1)]\} \quad (2)$$

Where $L(H_0)$ and $L(H_1)$ are the values of the corresponding rational function under the hypothesis H_0 and the alternative hypothesis H_1. If H_0 is evident, this test statistic is assumed to have an asymptotic distribution χ^2 with degrees of freedom equal to the number of constraints involved.

Some tests that have to be conducted to identify the best model including (i) choosing between the Cobb-Douglas production function and the superior Loga function; (ii) test whether technical inefficiencies exist; (iii) testing whether there is technological progress and if so, whether it is neutral.

3.2. Definition of High-tech Enterprises with Technology Spillover Ability

The set of high-tech enterprises with the ability to make technology spillover, denoted as Ω_t^*, used in this study is defined as (i) the enterprises that have machinery controlled either by human or computer (other than hand tools), (ii) the enterprises that have machinery imported from developed countries, with machine lifetime duration less than 10 years, and (iii) the enterprises that are among 50% enterprises with the largest TFP in the industry and in the year. The TFP criterion is included with the aim of eliminating low-productivity businesses, reflecting that low technological levels are unlikely to spillover. The criterion of origin (machinery imported from developed countries) is specified because not all machines imported from abroad are modern machines and are capable of spillover to other enterprises.

3.3. Methods of Measuring Technology Spillover Channels

Enterprise *i* is considered a technology spillover enterprise in year *t* if it is in the set of high-tech enterprises with technology spillover capacity Ω_t^* of year *t* as defined in section 2.2. Accordingly, the variable FH_{it} is equal to 1 if enterprise *i* of year *t* belongs to the technology spillover set Ω_t^* and it is 0 otherwise.

This study measures technology spillover in two groups of channels, which is horizontal technology spillover and vertical technology spillover. The total technology spillover effect (LH_{ijt}) reflects the presence of enterprise *i* with high technology in industry *j* at time *t*:

$$\mathrm{LH}_{it} = \frac{\mathrm{FH}_{it} \times X_{it}}{\sum_{j \in \Omega_t^*} X_{jt}} \quad (3)$$

Where *X* is the enterprise's sales revenue of enterprises extracted from the research data set. The horizontal technology spillover variable (LHhor_{jt}) in the same industry is measured as follows:

$$\mathrm{LHhor}_{it} = \frac{\sum_{i \in \Omega_t^*} \mathrm{LH}_{it} \times X_{it}}{\sum_{j \in \Omega_t^*} X_{jt}} \quad (4)$$

The backward technology spillover variable (LHback_{jt}) from high-tech enterprises to lower-tech suppliers is measured as follows:

$$\mathrm{LHback}_{jt} = \Sigma_{k,k \neq j}\, \gamma_{jkt} \times \mathrm{LHhor}_{kt} \quad (5)$$

Where γ_{jkt} is sector j's output rate supplying to sector *k* at time *t* (calculated from 2007's and 2012's *I-O* tables). The forward technology variable (LHfor_{jt}) from customers with lower technology level to enterprises providing high-tech input is measured as follow.

$$\mathrm{LHfor}_{jt} = \Sigma_{l,l \neq j}\, \delta_{jlt} \times \mathrm{LHh}_{lt} \quad (6)$$

Where δ_{jlt} is sector j's input rates purchased from the upstream sector l. The supply backward$_{jt}$ variable ($\mathrm{LHsback}_{jt}$), which captures the Markusen and Venables hypothesis, is measured as follows:

$$\mathrm{LHsback}_{jt} = \Sigma_{l,l \neq j}\, \delta_{jlt} \times \mathrm{LHback}_{it} \quad (7)$$

4. Empirical Results

4.1. Proposed Empirical Research Model

$$\begin{aligned}\mathrm{TE}_{it} &= \beta_0 + \beta_1 \mathrm{LH}_{ijt} + \beta_2 \mathrm{Spe}_{it} + \beta_3 \mathrm{LH}_{ijt} \times \mathrm{Abs}_{it} \\ &+ \beta_4 \mathrm{LH}_{ijt} \times \mathrm{R\,\&\,D}_{it} + \beta_5 \mathrm{LH}_{jit} \times \mathrm{link}_{it} + \beta_6 \mathrm{LH}_{ij} \\ &\times \mathrm{Ctrl}_{it} + c_1 + \mu_{it} \quad (8)\end{aligned}$$

Where *i*, *j*, *t* represent company *i* in industry *j* at time *t*, TE_{it} is the technical efficiency of firm *i* in year *t*, obtained from the estimation results of model (4).

LH_{ijt} is a vector representing technology spillover channels including the presence of a high-tech enterprise (LH), a horizontal spillover channel (LHhor), a forward spillover (LHfor), a backward spillover (LHback), and a supply backward spillover (LHsback).

Spe_{it} is a vector representing the typical variables of an enterprise including average firm income (LC) calculated by income per employee, external capital ratio (VNG) calculated by 1-equity/total capital, firm age (Age). Structure of ownership (SOE) is a dummy variable that takes the value of 1 if the firm is state-owned and 0 otherwise. Tax is the corporate income tax rate of business.

Interactive variables are included in the model in order to evaluate the interactive effects of technology spillover in three channels of horizontal spillover, forward spillover, and backward spillover corresponding to three different models.

The group of interactive variables between technology spillover channels and the ability to absorb technology of the business is measured by $LH_{ijt} \times Abs_{it}$, in which the group of variables representing the technology absorption capacity of the firm (Abs_{it}) includes (i) the variables reflecting the skills of workers (lackofskill), which is a dummy variable that takes the value of 1 if experiences and skills are the weakness of firm and 0 otherwise; (ii) the origin of imported machinery (advancedmachine), which is a dummy variable that takes the value of 1 if the two most important machinery and equipment of the enterprise are imported from a developed country and 0 otherwise; (iii) the level of technological machinery in the enterprise (lackofmachine), which is a dummy variable that takes the value of 1 if the equipment is a great weakness for the enterprise and is 0 otherwise.

The group of interactive variables between technology spillover channels and R&D activities of the enterprise is measured by $LH_{ijt} \times R\&D_{it}$, in which, the group of variables representing the R&D activities of the enterprise ($R\&D_{it}$) includes (i) the variable representing the R&D implementation of the enterprise (self R&D), which is a dummy variable that assumes the value of 1 if the enterprise conducts R&D activities by itself and 0 otherwise; (ii) the variable representing the enterprise's source of financing for R&D activities in the form of joint venture (joint venture), which is a dummy variable that assumes the value of 1 if the R&D budget of the enterprise is from the joint-venture source and 0 otherwise.

The group of interactive variables between technology spillover channels and the variables representing the vertical linkages between the supplier and the customer is measured as $LH_{ijt} \times link_{it}$, in which the group of variables representing this vertical linkage include (i) the transfer of skills and experiences of worker between the supplier and the customer (skilltrans), which is a dummy variable that assumes a value of 1 if the firm has a transfer of technology, skills, experience and 0 otherwise; (ii) the raw material source of the company is from Vietnam (VNsource), which is a dummy variable that takes value of 1 if the firm uses raw materials of Vietnam and 0 otherwise; (iii) the raw material source of the company is from China (CNsource), which is a dummy variable that takes the value of 1 if the enterprise uses Chinese materials and 0 otherwise; and (iv) the target audience of the enterprises (fdicustomer), which is a dummy variable that takes the value of 1 if the most important regular customer of the business is the FDI enterprise and 0 otherwise.

Another group of interactive control variables include the interactive variable between the technology spillover and the ownership type of business ($LH_{ijt} \times Ctrl_{it}$), in which, the control variable included in the study is fdi, which is a dummy variable that assumes the value of 1 if it is a foreign direct invested enterprise and 0 otherwise.

4.2. Source of Data

Data used in this study are collected from the annual survey data of the General Statistics Office of Vietnam (GSO). This is a balanced panel data on the production, operation and technology usage of manufacturing and processing enterprises including 19,432 observations over seven years, from 2012 to 2018 (2,776 enterprises in each year). The descriptive statistics of the variables included in the model are shown in Table 1.

Table 1: Descriptive Statistics of Variables

Variable	Sample of Manufacturing Companies During the Period 2012–2018		
	Mean	Standard Deviation	Skewness
VA	9517.011	31435.93	8.540
K	40891.32	152753.8	20.731
L	342.997	854.209	7.517
LH	0.0293	0.0207	8.931
LHhor	0.0294	0.0436	5.341
LHfor	0.0161	0.0246	3.816
LHback	0.0394	0.0590	1.828
LHsback	0.0170	0.0115	1.405
LC	14.912	15.264	32.381
VNG	0.586	0.954	52.612
Tax	0.205	0.016	1.527
Age	12.518	5.858	3.124
SOE	0.051	0.215	3.459
lack of machine	0.821	0.365	–1.457
advanced machine	0.414	0.435	–0.03
lack of skill	0.812	0.412	–1.701
VN source	0.825	0.351	–2.531
CN source	0.0837	0.274	3.046
fdi customer	0.186	0.345	1.785
joint venture	0.0004	0.024	35.775
self R&D	0.031	0.141	7.125
skill trans	0.281	0.128	–4.467
fdi	0.211	0.546	0.678

The descriptive statistics show that, among the technology spillover channels, the horizontal technology spillover channel has the largest mean value. The proportion of external business loans is about 58.6%. The research results also show that the lack of skills and machinery is a common situation of most businesses (over 80% encounter this problem). The enterprises mainly use domestically-produced materials with the rate 82.5%. Especially, research and development activities through joint ventures and external partners are still significantly modest.

4.3. Estimation Results

Table 2: Regression Estimation Results

Dependent Variable (TE)	(1) Horizontal Spillover LHhor	(2) Forward Spillover LHfor	(3) Backward Spillover LHback
1. Group of variables for technology spillover channels			
LH	0.629***	0.589***	0.579***
	(0.0362)	(0.0351)	(0.0293)
LHhor	–1.864***	–0.205***	–0.254***
	(0.240)	(0.017)	(0.03014)
LHfor	0.317	0.619***	0.179*
	(0.096)	(0.125)	(0.0940)
LHback	0.634***	2.734***	–3.016***
	(0.0529)	(0.311)	(0.316)
LHsback	0.307***	0.454***	0.463***
	(0.0216)	(0.0156)	(0.029)
2. Group of variables for characteristic of enterprises and State policies			
LC	0.00111**	0.00114**	0.00121*
	(0.0005)	(0.00052)	(0.0006)
VNG	–0.006***	–0.0063***	–0.00635**
	(0.0022)	(0.00245)	(0.00249)
Tax	0.964***	0.797***	1.0007***
	(0.0989)	(0.0969)	(0.0961)
Age	–0.0115***	–0.0107***	–0.00866***
	(0.0009)	(0.0008)	(0.00083)
SOE	0.0542***	0.0676***	0.0710***
	(0.0037)	(0.00471)	(0.00513)

Table 2: (Continued)

Dependent Variable (TE)	(1) Horizontal Spillover LHhor	(2) Forward Spillover LHfor	(3) Backward Spillover LHback
3. Interactive variable denotes the ability to absorb technology			
lantoa _ thieukynang	–0.322***	–1.036***	–0.151
	(0.110)	(0.175)	(0.139)
lantoa _ maytientien			0.308**
			(0.125)
lantoa _ thieumaymoc	–0.0442	–0.876***	–0.280*
	(0.143)	(0.216)	(0.151)
4. Group of interactive variables denotes R&D activities and collaborative research			
lantoa _ tunghiencuu	–0.9008	–0.297*	–0.466**
	(0.283)	(0.174)	(0.189)
lantoa _liendoanh	0.820***	0.573*	1.647***
	(0.214)	(0.287)	(0.153)
5. Group of interactive variable represents the linkage between the supplier and the customer			
lantoa_ chuyengiaokynang	0.215	0.346*	–0.121
	(0.210)	(0.161)	(0.100)
lantoa _nlieuvn		–0.0107***	
		(0.0021)	
lantoa _nlieuTQ		–0.420	
		(0.404)	
lantoa _khfdi			–0.847*** (0.016)
6. Group of interactive control variables			
lantoa_DNFDI	–0.0689	–0.295***	–0.216***
	(0.103)	(0.103)	(0.031)
Intercept	0.519***	0.522***	0.465***
	(0.031)	(0.0294)	(0.0169)
Number of observations	19.432	19.432	19.432
F-Staticstic	175.92***	141.64***	137.74***
Breuch & Pagan LM	3167.17***	3164.54***	3487.36***
Hausman	572.61***	889.16***	1241.19***
Modified Wald Test	2413.57***	2164.23***	2646.12***
Wooldridge test	65.78***	81.13***	55.064***
VIF	4.43	3.61	3.46

Note: ***, ** and * indicates significant at 1%, 5% and 10% level of significance based on *t*-statistics.

In order to select the most appropriate estimation method, the study carries out several diagnostic tests including Breusch-Pagan Lagrangian test to consider random effect model (REM) and Pooled OLS model, Hausman test to consider FEM and REM estimations, VIF test to examine the existence of multi-collinearity phenomenon, Wald test to examine the existence of heteroskedasticity, and Wooldridge test for the existence of autocorrelation issue. The test results show that the fixed-effects estimation is suggested to be consistent with the research dataset. In terms of diagnosing the model defects, it is determined that the model does not have multicollinearity issue, however, autocorrelation and heteroskedasticity problems exist. The diagnostic test results are presented at the bottom of Table 2. Additionally, to control the problem of heteroskedasticity and autocorrelation of the model, cluster with robust standard error will be applied for the fixed-effect estimation to mitigate such problems (Hoechle, 2007).

Table 2 presents the estimation results of the three models examining the interactive effects of technology spillovers on the efficiency of Vietnamese manufacturing enterprises (clustered to control model issues). In details, three different approaches were employed, including the interactive effects between horizontal technology spillover channels (model 1), forward technology spillover channels (model 2), and backward technology spillover channels (model 3), and the groups of variables affecting each corresponding technology spillover channel (Abs, R&D, link, ctrl).

4.3.1. The Impact of Technology Spillover Channels

In general, the variables representing the technology spillover channels are statistically significant and most of them give the same impact direction across all three models except for LHback variable in model 3. This shows that the models of technology spillover impact assessment are sufficiently stable and the impacts of the technology spillover variables are consistent even though they are tested in different scenarios. Accordingly, the total effect of technology spillover has a positive impact on the efficiency of Vietnamese manufacturing enterprises, in which the horizontal spillover channel witnesses a negative effect, while the forward spillover channel generally creates a positive impact on business efficiency. However, there is no evidence the backward channel has any impact on business efficiency.

In addition, the presence of high-tech enterprises brings a positive impact on the efficiency of Vietnamese manufacturing firms since the variable LH in all three models has 1% statistical significance. Specifically, the horizontal spillover channel (LHhor) shows a negative impact on the efficiency of Vietnamese manufacturing firms. This can be explained by the fact that Vietnamese manufacturing enterprises, with weak technological capacity and level, always face difficulties in machinery and technology, which is considered the biggest drawback that enterprises have to deal with. Furthermore, the ability to access capital to expand development and expertise is also weak, which means that the ability to absorb technology and the competitiveness of enterprises in the market is still limited. Thus, it reduces the capacity to generate horizontally spillover in businesses via learning and imitating activities. In addition, the emergence of high-tech enterprises with sufficient technology capabilities and qualifications can lead to better product quality and reduce demand for purchasing goods from low-tech businesses that will gradually loose their competitiveness and be pushed out of the market.

The forward technology spillover effect variable (LHfor) shows a positive impact on business efficiency. The input materials supplied to domestic enterprises in Vietnam are mainly raw materials purchased in the same province (accounting for 48.7%); domestic purchases account for over 80%. The availability of better inputs provided by the company with high technology, though the cost may be higher, will have the advantage of geographical distance to minimize costs for many domestic enterprises, playing an important role in increasing the productivity and efficiency of local businesses.

With the objective of receiving high-quality inputs, high-tech businesses can provide help to their suppliers such as transferring modern technology, encouraging technology spillover to create better quality of raw materials, and meet the requirements of the high-tech businesses (LHback coefficient is positive). Besides, competitive pressures and quality pressures will stimulate domestic firms to improve technology and invest in higher quality inputs (LHsback coefficient is positive). However, because the relationship between high-tech enterprises and the others is limited, the transfer of technology from high-tech enterprises to suppliers is relatively low, thereby hindering the possibility of backward spillovers.

4.3.2. The Impact of Firm and Industry Specific Variables

The estimation results show that, for most of Vietnamese manufacturing enterprises, the current situation is that the monitoring and management of capital and the capital structure are not properly arranged, leading to the fact that the larger the rate of external capital (represented by VNG), the less efficient of businesses in the industry. According to GSO's survey data, there are 88.35% of the enterprises in the manufacturing industry having financial difficulties such as credit and loans, especially among small- and medium-sized enterprises. The capital market has not yet developed, and capital-raising channels are still limited, which lead to difficulties in accessing sources of capital, thus, hindering the ability to expand production, improve technology, and reduce business investment opportunities, thereby negatively affecting business efficiency.

The higher the income per worker (LC), the greater the impact on the efficiency of the Vietnamese manufacturing firms. Therefore, improving salary in enterprises can be a solution to encourage employees to improve productivity, thereby increasing the efficiency of the business.

Vietnam's tax policy is gradually improved toward reducing corporate income tax rates to encourage and create conditions for businesses to operate and expand production. Since 2013, Vietnam's corporate income tax has been reduced from 32% to about 20% for large enterprises and 17% for small- and medium-sized enterprises, thus helping to improve the business performance. Along with that, the process of equitization and restructuring of state-owned enterprises has eliminated inefficient companies, thus increasing the overall efficiency of the industry.

It is worth noting that the coefficient of the enterprise age (Age) is negative. This means that a business in operation for a long time will become less efficient and negatively affect the overall efficiency of businesses in the industry and the economy. The inefficiency of these long-term businesses may be due to their cumbersome operating apparatus, experience-based management methods, slow innovation and adaptation to market changes, and slower access to existing technologies than younger businesses. Therefore, the older the businesses, the more negative impacts on the industry's efficiency.

4.3.3. The Impact of Interactive Variables on Technology Absorption

The interactive variables indicating the difficulty of skills and labor's experience and the difficulty of machinery and equipment are statistically significant with negative coefficients ($LH_{ijt} \times$ lack of $skill_{it}$ and $LH_{ijt} \times$ lack of $machine_{it}$). This is consistent with a number of studies (Keller, 1996; Wang, Liu, Cao, & Wang, 2016) as the quality of human resources and machinery and equipment affects technology spillover channels, which in turn affects business performance. Specifically, difficulties in labor skill and machinery will reduce the businesses' ability to absorb technology, greatly hinder the overall capacity to have technology spillover of the industry and, thereby, negatively affecting to business efficiency. Foreign enterprises importing modern machinery have the ability to create a large backward technology spillover and positively impact business efficiency. Suppliers with a higher level of technology will be able to create better products to meet the rigorous requirements of the market, of customers who are high-tech enterprises. In which, the skills of employees' experience have the strongest impact on the spillover capacity of the horizontal and forward channels.

4.3.4. The Impact of Interactive Variables on R&D Activities and R&D Cooperation

The estimation results show that the negative effect of technology spillovers in the forward and in the backward direction will be mitigated when the firms conduct research and development activities themselves (the coefficients of $LHfor_{ijt} \times selfR\&D_{it}$ and $LHback_{ijt} \times selfR\&D_{it}$ are negative). Joint-venture activities that share the cost of R&D implementation with their partners can help to increase the ability to have technology spillover as well as business efficiency (the coefficients of $LHfor_{ijt} \times jointventure_{it}$ and $LHback_{ijt} \times jointventure_{it}$) are positive). This result is also consistent with many studies (Wolfl, 2000; Porter & Stern, 1999). In fact, R&D activities carried out by enterprises are currently not effective while the investment costs in R&D are high, hence, it does not help improve many qualifications, technological capacity and efficiency of the business. The quality of human resources for R&D activities of enterprises is still limited (less than 1% of employees with doctoral degrees are directly involved in R&D activities) while the enterprise is isolating itself in its R&D activities rather than cooperating with others to absorb and share the positive spillover elements. Thus, it limits the ability to absorb technology as well as reduce efficiency in R&D activities of the firms. Joint venture and cooperation in R&D are important channels to improve qualifications and capacity to increase the technology spillover of companies, while it also helps them to reduce R&D costs. Additionally, their employees can also improve their qualifications and skills. Enterprises can take advantage of high-quality external resources to help the effects of the horizontal spillover channel and backward spillover channel more positive and accordingly affecting the business efficiency. However, barriers to finance, administrative procedures, mechanisms, and mismatching of needs when establishing cooperative relations in R&D with external organizations can be the biggest difficulties causing this type of cooperation not being popular (R&D funding from joint ventures only accounts for 0.62% of the total R&D expenditure of the industry).

4.3.5. The Impact of Interactive Variables on the Linkage of Supplier and Customer

Interdisciplinary spillovers (between supplier and customer) through forward or/and backward linkages (Javorcik, 2004; Alfaro, Rodriguez-Clare, Hanson, & Bravo-Ortega 2004) are important spillover channels that influence the productivity of business. The research results show that positive externalities in the forward direction will be higher for businesses that already had linkage in technology and labor's skills transfer with suppliers (the coefficient of $LHfor_{ijt} \times skilltrans_{it}$ are positive). This result is also consistent with the research by Newman, Rang, and Talbot (2015). Meanwhile, the transfer of technology, skills and experience of workers does not show the impact in other technology spillover channels. The transfer of skills and experience is an important channel to increase the spillover capacity of business, however, it may be due to the relationship between parties in the supply chain such as the relationship between high-tech customers and suppliers is not close enough, hence, the high-tech enterprises often limit the transfer of technology and skills to workers to the lower technology suppliers.

Origin of input materials can also be considered as a factor affecting the technology spillover. The estimated results show that the input material source of Vietnam ($LHfor_{ijt} \times VNsource_{it}$) is a factor that reduces the technology spillover in the forward direction. The reason is that the supporting industries of Vietnam are still underdeveloped, hence, the input products provided by Vietnam's low-tech enterprises are poor in quality, fewer in types, and not yet meeting the requirements of the market. Therefore, the ability to have technology spillover from this group of enterprises is almost absent. Besides, raw materials from China account for a large proportion in the structure of imported foreign raw materials of Vietnamese enterprises but the impact has not yet been shown.

The study results also show that the FDI customers have a negative impact on the ability to provide technology spillover of the business. In terms of the backward spillover channels, the variable $LHback_{ijt} \times fdicustomer_{it}$ has a negative coefficient and $LH_{ijt} \times fdi_{it}$ is also the same. This can be explained by the fact that the FDI enterprises do not transfer, or even if they do transfer modern technology and machinery, the domestic firms still cannot produce products that meet the expected international quality. Hence, this significantly limits the ability to take advantage of technology spillover from FDI companies.

5. Conclusion

The study evaluates the interactive effects of technology spillover channels on the efficiency of Vietnamese manufacturing firms. The estimation results show the following: Firstly, the total effect of technology spillovers has a positive impact on the efficiency of Vietnamese manufacturing enterprises, in which the horizontal spillover channel has a negative effect while the forward spillover has a positive impact on enterprise efficiency, yet the backward spillover channel presents unclear results in different models. Secondly, the labor's skills and experience difficulties of enterprises are the biggest barrier affecting the ability to make technology spillover horizontally and forwardly. Thirdly, in-house research and development activities of businesses limit the ability to spillover their technology and improve business efficiency, while different forms of joint ventures with outside organizations in R&D can help increase the ability to spillover technology of the business. Fourthly, the transfer of skills and experience in businesses has not shown a clear impact except for a positive impact on the technology spillover channel in the forward direction. Fifthly, the presence of FDI enterprises is limiting the technology spillover of local firms within the industry and negatively affecting the efficiency of the whole sector. In order to increase the technology spillover of businesses and improve the efficiency of the industry, both businesses and governments need to clearly define the importance of knowledge, workers' qualifications, and technological innovation in enterprises, which is the key to increase the ability of businesses to absorb technology and accelerate the process of catching up with global technology. On the one hand, businesses need to diversify their technology innovation strategies, be more open to better access to external knowledge sources, focus on cooperation methods to share funds with other organizations, and consider universities as significant means of contribution to business development. On the other hand, the government also needs to strongly strengthen different forms of supporting cooperation between enterprises and research institutes, universities in R&D activities, create communication channels and network links between enterprises and research organization. In addition, the government needs to perfect the mechanisms and policies to support small- and medium-sized enterprises to improve their technology absorption capacity and strengthen the linkages between industrial parks, FDI companies, high-tech, and domestic firms.

References

Alfaro, L., Rodríguez-Clare, A., Hanson, G., & Bravo-Ortega, C. (2004). Multinationals and Linkages: An Empirical Investigation [with Comments]. *Economía*, *4*(2), 113–169. http://www.jstor.org/stable/20065460

Antonelli, C. (1994). Localized technological change and the evolution of standards as economic institutions. *Information Economics and Policy*, *6*(3–4), 195–216. https://doi.org/10.1016/0167-6245(94)90002-7

Battese, G. E., & Coelli, T. (1995). A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data. *Empirical Economics*, *20*(2), 325–332. https://doi.org/10.1007/BF01205442

Bonte, W. (2008). Inter-firm trust in buyer-supplier relations: Are knowledge spillovers and geographical proximity relevant? *Journal of Economic Behavior & Organization*, *67*(3–4), 855–870. https://doi.org/10.1016/j.jebo.2006.12.004

Cohen, W. M., & Levinthal, D. A. (1989). Innovation and learning: The two faces of R&D. *The Economic Journal, 99*(397), 569–96. https://doi.org/10.2307/2233763

Czarnitzki, D., & Kraft, K. (2012). Spillovers of innovation activities and their profitability. *Oxford Economic Papers*, *64*(2), 302–322. https://doi.org/10.1093/oep/gpr020

Do, A. D., Nguyen Q. V., Le, Q. H., & Ta, V. L. (2020). Green Supply Chain Management in Vietnam Industrial Zone: Province Level Evidence. *Journal of Asian Finance, Economics and Business*, *7*(7), 403–412. https://doi.org/10.13106/jafeb.2020.vol7.no7.403

Fu, X., & Gong, Y. (2009). Absorptive capacity and the benefits from global reservoirs of knowledge: evidence from a linked China-OECD dataset. *ALPTMD working paper series; No. 31*. University of Oxford.

Glass, J., A., & Saggi, K. (1998). International Technology Transfer and the Level of Technology. *Journal of Development Economics, 55*, 369–98.

Griliches, Z. (1957). Hybrid Corn: An exploration in the economics of technical change. *Econometrica*, *25*(4), 501–522. https://doi.org/10.2307/1905380

Guo, B. (2007). Technological development, technology spillover and profitability: An industry level empirical analysis of Chinese manufacturing industries. *Technology Analysis and Strategic Management, 17*(3), 279–292. https://doi.org/10.1080/09537320500211268

Hassan, A., Ahsan, A. K., Danial, S. P., Wajiha, A., & Zahoor (2011). Sarwar Technology spillover impacts on total productivity of the manufacturing sector in Pakistan. *African Journal of Business Management*, *6*(9), 3490–3503. https://doi.org/10.5897/AJBM11.2352

Hoang, D. T., Do, A. D., & Trinh, M. V. (2020) Spillover effects of FDI on technology innovation of Vietnamese Enterprises. *Journal of Asian Finance, Economics and Business*, *8*(1), 655–663. https://doi.org/10.13106/jafeb.2021.vol8.no1.655

Hoang, V. P., & Pham, T. H. (2010). Productivity Spillovers from Foreign Direct Investment: The case of Vietnam, In: Hahn, D. N., & D. Narjoko (Eds.), *Causes and Consequences of Globalization in East Asia: What Do the Micro Data Analyses Show?* (pp. 228–246), ERIA Research Project Report 2009-2, Jakarta, Indonesia: ERIA.

Hoechle, D. (2007). Robust standard errors for panel regressions with cross-sectional dependence, *Stata Journal*, *7*(3), 281–312. https://doi.org/10.1177/1536867X0700700301

Javorcik, B. S. (2004). Does Foreign Direct Investment increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages. *American Economic Review, 94*(3), 605–627. https://doi.org/10.1257/0002828041464605

Keller, W. (1996). Absorptive capacity: On the creation and acquisition of technology in development. *Journal of Development Economics*, *49*(1), 199–227. https://doi.org/10.1016/0304-3878(95)00060-7

Keller, W., & Yeaple, S. R. (2009). Multinational Enterprises, International Trade, and Productivity Growth: Firm Level Evidence from the United States. *The Review of Economics and Statistics, 91*(4), 821–831. https://doi.org/10.1162/rest.91.4.821

Kenta, I., Rene, B., Fukao, K., Young, G. K., & Kwon, H. U. (2015). Buyers, Suppliers, and R&D Spillovers. *RIETI Discussion Paper Series 15-E-047*. Retrieved September 08, 2018, from: https://www.rieti.go.jp/jp/publications/dp/15e047.pdf

Kitson, A. (2001). Nursing Leadership: Bringing Caring Back to the Future. *Quality in Health Care*, *10*, 79–84. https://doi.org/10.1136/qhc.0100079

Klette, T. J. (1994). R&D, Spillovers and Performances among Heterogeneous Firms – An Empirical Study Using Microdata. *Discussion Paper No. 133,* Research Department, Statistics Norway. Retrieved September 12, 2018, from: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.986.4322&rep=rep1&type=pdf

Liu, X., Wang, C., & Wei, Y. (2009). Do local manufacturing firms benefit from transactional linkages with multinational enterprises in China. *Journal of International Business Studies, 40*(7), 1113–1130. https://doi.org/10.1057/jibs.2008.97

Mansfield, E. (1968). *Industrial Research and Technological Innovation*. Norton, NY: Edwin Mansfield.

Medda, G., & Piga, C. A. (2014) Technological spillovers and productivity in Italian manufacturing firms. *Journal of Productivity Analysis*, 41, 419–434. https://doi.org/10.1007/s11123-013-0351-1

Newman, C., Rang, J., & Talbot, T. (2015). Technology transfer, foreign investment and productivity spillovers. *European Economic Review*, *75*, 168–187. https://doi.org/10.1016/j.euroecorev.2015.02.005

Nguyen, Q. A. M. (2009). FDI – opportunities and challenges for domestic businesses. *Journal of Economics and Development, 149*, 33–41.

Nguyen, K. M., Nguyen, V. H., & Tran, T. T. H. (2014). How Does Technology Diffusion Increase Speed of TFP Convergence at Firm level? Exploring the Effects of High Technology Firms on Linkages: Evidence from Vietnam Enterprises. *Global Journal of Management and Business Research: Economics and Commerce, 14*(9) 9–19. Retrieved September 13, 2018, from: https://journalofbusiness.org/index.php/GJMBR/article/view/1514/1421

Nishimura, K. G., Nakajima, T., & Kyyota, K. (2005). Productivity Convergence at the Firm Level. Retrieved July 01, 2017, from http://www.e.u-tokyo.ac.jp/cirje/research/03research02dp.html

O'Donnel, C. J., Rao, D. S. P., & Battese, G. E. (2008). Meta-frontier Frameworks for the study of firm level efficiencies and technology ratios. *Empirical Economics*, *34*(2), 213–55. https://doi.org/10.1007/s00181-007-0119-4

Porter, M. E., & Stern, S. (1999). *The New Challenge to America's Prosperity: Findings from the Innovation Index*. Washington (DC): Council on Competitiveness.

Romer, P. (1990). Endogenous technological change. *Journal of Political Economy*, *98*(5), 71–101. https://www.jstor.org/stable/2937632

Schoors, K., & Merlevede, B. (2007). FDI and the Consequences. Towards more complete capture of spillover effects. *Ghent University Working paper No. 372.* Retrieved September 15, 2018, from: https://doi.org/10.2139/ssrn.1086187

Solow, R. M. (1956). A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics, 70*(1), 65–94. https://doi.org/10.2307/1884513

Solow, R. M. (1957). Technical Change and the Aggregate Production Function. *The Review of Economics and Statistics, 39*(3), 312–320. https://doi.org/10.2307/1926047

Suyanto, R. A., Salim, R., & Bloch, H. (2009). Does Foreign Direct Investment Lead to Productivity Spillovers? Firm Level; Evidence from Indonesia. *World Development, 37*(12), 1861–1876. https://doi.org/10.1016/j.worlddev.2009.05.009

Ta, V. L., Le, Q. H., Nguyen, T. L. H., Phan, T. T., & Do, A. D. (2020). Investigating foreign direct investment attractive factors of Korean direct investment into Vietnam. *Journal of Asian Finance, Economics and Business*, *7*(6), 117–125. https://doi.org/10.13106/jafeb.2020.vol7.no6.117

Tran, T. T. (2011). Productivity Spillovers from Foreign Direct Investment. What if Productivity is No Longer a Black Box? *The South East Asian Journal of Management, 5*(1), 1–18. https://doi.org/10.21002/seam.v5i1.1792

Wang, H., Liu, H., Cao, Z., & Wang, B. (2016). FDI technology spillover and threshold effect of the technology gap: regional differences in the Chinese industrial sector. *Springer Plus*, 5, Article number 323. https://doi.org/10.1186/s40064-016-1962-6

Watanabe, C., Bing, Z., & Asgari, B. (2001). Global Technology Spillover and its Impact on Industry's R&D Strategies, *Technovation, 21*(5), 281–91. https://doi.org/10.1016/S0166-4972(00)00048-1

Wolfl, A. (2000). Spillover Effects and R&D-Cooperations – The Influence of Market Structure. *IWH Discussion Papers 122, Halle Institute for Economic Research (IWH).* Retrieved August 18, 2019, from: https://www.iwh-halle.de/fileadmin/user_upload/publications/iwh_discussion_papers/122.pdf

Worthington, A. C., & Lee, B. L. (2008). Efficiency, technology and productivity change in Australian universities 1998-2003. *Economics of Education Review*, *27*(3), 285–298. https://doi.org/10.1016/j.econedurev.2006.09.012