Technological Spillovers and Determinants of Firm Productivity : Evidence from Vietnam's Manufacturing Industry

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Abstract

The paper aimed to study the determinants and spatial spillovers of enterprise productivity in the manufacturing industry in Vietnam during the period from 2010 – 2019. The spatial regression model was used to estimate the spatial dependence of enterprise-level TFP. The results showed that technology spillover occurred positively among firms in the region, and this effect decreased rapidly with spatial distance. Furthermore, the results also showed that firm productivity depended on firm characteristics and local market conditions. Further analysis showed that spillover effects' strength was affected by many other factors: area, presence of FDI, administrative policies, border effect, infrastructure, weak financial factors, utility services, and human resources. These factors created favorable conditions for the smooth connection between major economic centers, creating strong inter-regional spillover effects. From the findings, the study proposed important policy implications.

Keywords : **R&D, spillover, total factor productivity, Vietnam**

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Economic growth based on total factor productivity (TFP) growth has always been one of the widely debated topics in the literature from both a micro and macro perspective. At the micro-level, TFP depends on many other factors: access to foreign markets, enterprise-level innovation, ownership structure (Aitken & Harrison 1999; Griffith et al., 2004), and external market conditions, especially agglomeration economies (Syverson, 2011). The conception of agglomeration is considered the foundation for industrial growth and firm performance (Henderson, 2003). Since then, the NEG theory (Behrens et al., 2014; Duranton & Puga, 2004; Krugman, 1991; Roy & Das, 2018; Singh, 2016) has developed multiple microscopic foundations of agglomeration economies.

Although there are many successful experiments in determining the specific mechanisms of productivity convergence, the early literature considered convergence as an intermediate good and ignored the spatial interaction between businesses. Rosenthal and Strange's (2003) pioneering assertion of spatially pervasive productivity convergence with microdata inspired subsequent empirical studies. Since then, the spillover effect within and outside the province border has been considered as one of the common effects when studying regional/local economies. At the enterprise level, spatial spillovers are often determined based on how the benefits

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of convergence over different distances are estimated (Arzaghi & Henderson, 2008; Rosenthal & Strange, 2003). Some other studies have estimated spatial spillovers by performing this firm productivity regression depending on the characteristics of the remaining firms (Dhamija & Singh, 2018; Himanshu & Anand, 2019; Verma & Kaur, 2018). However, this method failed to show direct evidence of spatial productivity spillovers.

For Vietnam, research on technology spillover has been carried out recently and mainly focused on testing spillover effects. Le (2005) examined the spillover channels from FDI in Vietnam. The estimation results showed that the panel data estimation method helped control the estimation bias compared with the OLS method. However, using industry-level data with a relatively small sample size may affect the reliability of the results. Similarly, Truong et al. (2015) also applied the panel data estimation method but obtained new contributions when testing the impact of trade protectionism and FDI characteristics on spillover effects. The results showed that the import restriction policy reduced productivity and absorbed spillover from the FDI of domestic enterprises. Nguyen and Nguyen (2012) also tested vertical and horizontal technology spillover channels for 31,509 manufacturing enterprises in Vietnam for the time period from 2000 – 2005. The results showed that FDI had a positive impact on the productivity of domestic firms. However, the results obtained did not find vertical and horizontal spillover effects. In general, most domestic studies focused on technology spillover effects from FDI rather than other factors such as R&D and exports and ignored the spatial interaction of firm productivity across regions. The purpose of linearizing the parameters in the analytical model should lead to contradictory statements (Nguyen & Pham, 2016). Therefore, it is necessary to review the technology spillover effects from the transmission channels. The proposed study attempts to interpret the findings related to domestic firm productivity.

This study differs from previous studies in the following points. Firstly, the spatial factor in the dataset is considered for conducting an in-depth analysis of the spatial dependence of firm productivity. Second, in the empirical model's specification, it is possible to calculate the individual spillover effects of different firms inside and outside the region. Third, the study examines whether technology spillovers within and outside the region respond to geographical factors.

Methodology

It is common in firm productivity analysis to estimate the firm-level TFP aggregate productivity and use it as the dependent variable. In the study, the semi-parametric method of Levinsohn and Petrin (2003) is used because it allows us to separate the contribution of factors (labor, capital) in growth from the rest, which is the contribution of TFP, and the higher the magnitude of the TFP parameter, the more efficient the economy is and vice versa.

The Spatial Fixed Effects Model

This study examines the spatial spillover effect of firm productivity (TFP) of the manufacturing sector in Vietnam. Based on the general spatial model (LeSage & Pace, 2009), the research proposes to choose the spatial autoregressive model (SAR) as the empirical analysis model:

$$Y_t = \lambda W_t Y_t + X_t \beta + \alpha I_t + \mu_t + u_t, \qquad (1)$$
$$u_t = \rho M_t u_t + \varepsilon_t$$

Here,
t denotes time in years of observation;
N_t denotes the number of observations of the data in the tth time year;
Y_t is the dependent variable on time t;

W_t and M_t are two spatial weight matrices with the same level ($N_t \times N_t$);
X_t is known to be a matrix ($N_t \times K$) of K exogenous regression, and it represents a vector ($N_t \times 1$) of all vectors. The quantity μ_t is a time-invariant ($N_t \times 1$) individual effect vector. Finally, the term u_t error is considered due to the automatic restoration of the space created with i.i.d. with the noise quantity ε_t having zero mean and variance σ^2.

Regressively superimposing the equations over time, we get a spatial model with fixed effects:

$$y = \lambda . Wy + X.\beta + \alpha .I + \mu + u, \quad (2)$$
$$u = \rho . M.u + \varepsilon$$

The structural parameters δ (λ, β', α)$'$ of Model (2) are estimated by the two-stage least squares method 2SLS, denoted as $\hat{\delta}_W$ (Kelejian & Prucha, 1998).

Spatial Random Effects Model

With assumptions cov (μ, X) = 0, the spatial fixed effects model is replaced by the spatial random effects model specification:

$$y = \lambda Wy + X\beta + \alpha I + u, \quad (3)$$
$$u = \rho Mu + \mu + \varepsilon$$

Kelejian and Prucha (1998) proposed a method to estimate the structural parameters $\hat{\delta}_R$ of Model (3) according to the FG2SLS procedure. The FG2SLS procedure applied to spatial models with random effects is more suitable than spatial models with fixed effects (Mutl & Pfaffermayr, 2011).

Data and Variables

The study uses panel data collected from comprehensive firm surveys conducted by the General Statistics Office (GSO) in 2011–2013, 2014–2016, and 2017–2019 for Vietnam's manufacturing sector. This data set provides information about the geographical location of each firm, covers almost all of Vietnam, and can be considered the best data set available for empirical research, especially in the study of firm productivity.

The primary geographical unit in this study is the province/city directly under the Central government, defined in the book of administrative units (National Standard TCVN/TC 46). Using the administrative code, the location of each business in the province/city in which it operates could be obtained. The study uses one format file for all district (county) jurisdictions and above. This geographical file allows the survey to build spatial relationships between jurisdictions according to the contiguity between administrative centers.

Data on local governments' budgetary expenditures (Puh) were collected from the Ministry of Finance. The master dataset was merged by matching administrative codes. After these steps, a data set of 36,420 different enterprises in 22 manufacturing industries in 789 districts across the country was obtained. The dataset provides almost complete coverage of industrial firms of all sizes throughout Vietnam from 2010 – 2019.

Vietnam's manufacturing industry was chosen to study spillover effects for the following reasons. Firstly, the manufacturing industry group is intensive, so the technology spillover effect is easier to detect. Second, the industry provides a large sample with a broad spatial extent that allows analysis to be carried out without the burden of data loss. Thirdly, the spatial distribution of firms and job clusters is often concentrated in industrial zones under provinces/cities. This observation suggests that spatial interoperability occurs strongly between firms when they are close.

According to the above argument, each firm has two neighbors: intra-regional and inter-regional firms. Therefore, the study builds two types of spatial weight matrices corresponding to two kinds of neighbors for the model (SAR) as follows:

$$W_{1t}\, y_{itk} = \sum_{\substack{j \in F_t(k) \\ j \neq i}} E_{jkt}.y_{jkt} \Big/ \sum_{\substack{j \in F_t(k) \\ j \neq i}} E_{jkt}, \qquad (4)$$

$$W_{2t}\, y_{itk} = \sum_{\substack{j \in F_t(k') \\ k' \in N(k)}} E_{jk't}.y_{jk't} \Big/ \sum_{\substack{j \in F_t(k') \\ k' \in N(k)}} E_{jk't}, \qquad (5)$$

where,

t denotes time in years;

The indices k and k' denote the provinces k and k';

Indices i and j represent i and jth firms;

$F_t(k)$ is the set of firms located in province k in year t;

$N(k)$ is the set of neighboring provinces of province k;

y is the weighted variable of interest;

E_{ikt} is the employment of the ith firm of province k in year t.

SAR model (1) is considered with two exogenous variables: business characteristics and market factor variables. Firm characteristics are considered an indicator of absorption capacity and have an important influence on technology spillover, including fixed factors such as *R&D* and *EX*. Accordingly, market factors include a level of localization economy *(Spec)*, industrial labor density *(Dsty)*, level of competition *(HHI)*, and local expenditure *(Puh)*. *Dsty* is determined by the natural logarithm of the total number of industrial workers per area (Glaeser et al., 1992; Pandey & Pattanayak, 2018). *Puh* is determined by the logarithm of the total budget (Himanshu & Anand, 2019). Finally, *HHI* is determined according to the Herfindahl – Hirschman index (Combes et al., 2004) :

$$HHI_{kt} = \sum_{i \in F_t(k)} \left[\frac{E_{ikt}}{\sum_{i \in F_t(k)} E_{ikt}} \right]$$

Table 1 summarizes the definitions and measures of variables in the enterprise productivity research model. Yu et al.'s (2013) approach is used to assume that market factors affect businesses in neighboring areas. Accordingly, the spatially lagged components: $W_{2t}\,Spec_{kt}$, $W_{2t}\,Dsty_{kt}$, W_{2t}, HHI_{kt}, and $W_{2t}\,Puh_{kt}$ of the market factor

Table 1. *Definitions of the Measurement Variables in the Model*

Variable	Proxy	Measurement of Variables
Total factor productivity	*TFP*	According to the semi-parametric algorithm of Levinsohn – Petrin
Research and development	*R&D*	The ratio of intangible assets of the business to fixed assets
Exports	*EX*	The ratio of exports to revenue of the enterprise
Localization economies	*Spec*	The location quotient of industry in the province
Industrial employment density	*Dsty*	Measured by the manufacturing quotient/industries in the province
Competition	*HHI*	According to the Herfindahl – Hirschman index
Public expenditure	*Puh*	The total budget expenditure in the province

Table 2. ***Descriptive Statistics of Variables***

Variable	Mean	Std.	Min	Max
Tfp	5.721	1.172	– 2.292	11.721
W_1Tfp	7.381	0.884	– 0.830	10.381
W_2Tfp	7.494	0.725	2.494	11.194
R&D	0.053	0.183	0.000	1000
EX	0.189	0.352	0.000	1000
Spec	1.231	2.090	0.006	12.231
Dsty	2.654	1.454	– 0.505	9.654
HHI	0.153	0.173	0.006	0.853
Puh	7.014	1.324	6.013	13.013
W_2 *Spec*	1.221	1.621	0.007	12.221
W_2 *Dsty*	2.646	1.246	– 0.505	7.646
W_2 *HHI*	0.145	0.171	0.008	0.745
W_2 *Puh*	7.012	1.534	0.000	12.012

are also included in the model to find the spillover determinant. Finally, the experimental model is rewritten as follows :

$$Tfp_{ikt} = \beta_1 R\&D_{ikt} + \beta_2 EX_{ikt} + \beta_3 Spec_{ikt} + \beta_4 Dsty_{ikt} + \beta_5 HHI_{ikt} + \beta_6 Puh_{ikt} + \beta_7 W_{2t} Spec_{kt} + \beta_8 W_{2t} Dsty_{kt} + \beta_9 W_{2t} HHI_{kt} + \beta_{10} W_{2t} Puh_{kt} + \lambda_1 W_{1t} Tfp_{ikt} + \lambda_2 W_{2t} Tfp_{ikt} + \alpha + u \quad (6)$$

In practice, the study only selected firms with both types of neighbors simultaneously. After excluding firms that lacked the necessary parameters, the panel dataset included in the analysis included more than 36,420 observations. Table 2 shows a significant difference between the firm-specific variables: *EX, R&D, TFP*, and lags of *TFP*. The market factor variables and their lags are little changed, proving that the firm-specific factor has a more pronounced effect on its productivity than the market factor.

Empirical Analysis and Results

Table 3 summarizes the results of the empirical model (6) by different methods, respectively: OLS, 2SLS, GMM, FG2SLS, respectively in Column 1 – Column 4 of Table 3. The estimates in Column 2 follow the procedure. The 2SLS procedure gives different results than the estimates in Column 1 by the OLS method. Although there are differences between the two 2SLS methods for GMM, the estimation results in Column 3 and Column 2 are the same. The 2SLS method is preferred because of its more straightforward implementation. Comparing the results of Column 2 and Column 4 reveals that the empirical evidence supports the fixed effects model. Therefore, the fixed effects model (FE-2SLS) is chosen as the basis for further inferences.

According to the estimation results, the coefficient of the intra-regional spillover effect is $\hat{\lambda}_1 = 0.351$ and is highly significant. Hence, it is implied that firm-level TFP increases by 3.5% if intraregional neighbors increase uniformly by 10%; $\hat{\lambda}_2 = 0.094$ which shows that the inter-regional spillover coefficient is smaller than the intra-regional spillover coefficient and is not statistically significant. This coefficient reinforces the perception that the technology spillover effect positively affects local businesses and weakens distance. This means technology

Table 3. ***Regression Results of the Baseline Model***

Regressor	Panel (1) FE	Panel (2) FE–2SLS	Panel (3) FE–GMM	Panel (4) RE–2SLS
W_1Tfp	**0.191***	**0.351****	**0.358****	**0.675****
	(0.011)	(0.077)	(0.076)	(0.009)
W_2Tfp	**0.168****	**0.094**	**0.097**	**0.128****
	(0.016)	(0.084)	(0.082)	(0.009)
R&D	**0.164****	**0.174****	**0.168****	**0.403****
	(0.028)	(0.030)	(0.030)	(0.016)
EX	**0.081***	**0.085****	**0.085****	**0.073****
	(0.026)	(0.028)	(0.027)	(0.008)
Spec	**0.030****	**0.007**	**0.008**	**– 0.011***
	(0.009)	(0.015)	(0.015)	(0.002)
Dsty	**0.215****	**0.181****	**0.168****	**– 0.009****
	(0.022)	(0.025)	(0.026)	(0.002)
HHI	**– 0.602****	**– 0.756****	**– 0.767****	0.125**
	(0.075)	(0.125)	(0.123)	(0.016)
Puh	**0.129****	**0.087****	**0.096****	**0.004**
	(0.013)	(0.023)	(0.023)	(0.002)
W_2 *Spec*	**– 0.028****	**– 0.016**	**– 0.013**	**– 0.033****
	(0.009)	(0.012)	(0.012)	(0.002)
W_2 *Dsty*	**0.042****	**0.056****	**0.066****	**– 0.026****
	(0.016)	(0.015)	(0.016)	(0.003)
W_2 *HHI*	**– 0.597****	**– 0.439****	**– 0.417****	**0.019**
	(0.078)	(0.121)	(0.017)	(0.018)
W_2 *Puh*	**0.019****	**0.015****	**0.015****	**0.002**
	(0.006)	(0.007)	(0.006)	(0.002)
Intercept	**1.135****	**1.029****	**1.011****	**1.294****
	(0.145)	(0.175)	(0.175)	(0.040)
R^2	**0.023**	**0.024**	–	**0.733**
$\hat{\sigma}_\mu$	**1.236**	**1.224**		**1.352**
$\hat{\sigma}_u(\hat{\sigma}_\varepsilon)^c$	**0.666**	**0.667**		**0.565**
$\hat{\rho}$				**– 0.954**

Note. Standard errors in parentheses; Significance codes: '**' 0.05, '*' 0.10.

spillover will be approached by the nearer provinces first and then later to the more distant provinces through production factors.

The coefficients, R&D and EX are 0.174, 0.085, respectively, with high significance. It shows that when R&D and EX activities increase by 10%, productivity increases by 1.74% and 0.8%, respectively. The coefficient of Spec is 0.007, which is small and insignificant. The coefficients of Dsty, HHI are 0.181, – 0.756, which have high significance, respectively. The value of 0.181 indicates that a 10% increase in employment density will increase

Table 4. ***The Influence of Geographical Factors on Technology Spillover***

Variable	**1**	**2**	**3**	**4**	**5**	**6**	**7**
W_1Tfp	**0.335****	**0.296****	**0.347****	**0.281****	**0.347****	**0.287****	**0.276****
	(0.075)	(0.068)	(0.077)	(0.072)	(0.073)	(0.071)	(0.074)
W_2Tfp	**0.112**	**0.122***	**0.066**	**0.161****	**0.112**	**0.116***	**0.154****
	(0.083)	(0.072)	(0.073)	(0.074)	(0.076)	(0.065)	(0.072)
Interactions							
W_1Tfp × Large	**0.327****			**0.364****	**0.284****		**0.309****
	(0.074)			(0.085)	(0.065)		(0.076)
W_2Tfp × Large	**– 0.204****			**– 0.364****	**– 0.139****		**– 0.219****
	(0.078)			(0.093)	(0.068)		(0.081)
W_1Tfp × County		**0.266****		**– 0.028**		**0.184****	**0.034**
		(0.061)		(0.068)		(0.058)	(0.068)
W_2Tfp × County		**–0.072**		0.212*		**0.014**	**0.159****
		(0.065)		(0.081)		(0.061)	(0.081)
W_1Tfp × Border			**– 0.215****		**0.086**	**0.236****	**0.126**
			(0.097)		(0.094)	(0.097)	(0.091)
W_2Tfp × Border			**– 0.247****		**– 0.178***	**– 0.306****	**– 0.240****
			(0.097)		(0.092)	(0.101)	(0.090)
R^2	**0.121**	**0.125**	**0.119**	**0.124**	**0.119**	**0.121**	**0.124**
$\hat{\sigma}_\mu$	**1.279**	**1.257**	**1.254**	**1.286**	**1.334**	**1.283**	**1.341**
$\hat{\sigma}_u$	**0.680**	**0.668**	**0.671**	**0.672**	**0.673**	**0.671**	**0.672**

Note. Standard errors in parentheses; Significance codes: '**' 0.05, '*' 0.10.

the productivity of local businesses by 1.81%. Similarly, – 0.756 indicates that if HHI increases by 10%, firms' productivity will decrease by 7.56%. The coefficient of Puh, which is 0.087, is statistically significant, indicating that a 10% increase in local public expenditure will increase TFP by 0.09%. The results also show that the spatial lag of the variables: Spec, Dsty, HHI, and Pub also affect the TFP yield but is weaker than that of the variables without delay. It shows technology spillover between the intra-regional market and the inter-regional neighboring market (Rosenthal & Strange 2003). In summary, the baseline model shows a powerful technology spillover in neighboring provinces and a gradual decline with geographical distance. Next, to examine whether geographical factors, administrative division, and provincial border affect the strength of technology spillover, the study expands the baseline model.

The study extends the model (6) by adding large, county, and border dummy variables based on the above statement. These variables will interact with the additional W_1Tfp and W_2Tfp. The estimated results of the extended baseline model with the interacting variables according to the FE-2SLS process are presented in Table 4.

Columns 1 – 3 present the estimation results of the base model with each variable: large, country, and border added. The results show that the interaction coefficient of W_1Tfp × Large and W_2Tfp × Large is 0.327, – 0.204, respectively, with high statistical significance. W_1Tfp × Border and W_2Tfp × Border are not statistically significant but are correct about the sign expectation. It shows that the region's area affects technology spillover, which gradually decreases through the border effect. Columns 4 and 7 show that the coefficient W_1Tfp × County is small and not statistically significant; the coefficient W_2Tfp × County is significant, but with opposite signs. It shows that inflexible administrative policies have limited the power of technology spillover. Finally, to see whether the factors of transport infrastructure, FDI, industrial services, and quality of education affect the strength of technology spillover, the study will continue to expand the model.

Another reason hindering inter-regional spillover is infrastructure. Good transportation infrastructure will reduce freight costs. Similarly, advances in information technology reduce communication costs. These two types of infrastructure make distance less critical in promoting technology spillovers across regions (Yu et al., 2013). In addition, the role of FDI in Vietnam's production is desirable to contribute positively to the technology spillover effect. Thus, the factor FDI is introduced in the model. Finally, two other factors that influence technology spillovers, including business services and human capital (Ke et al., 2014; Moretti, 2004), are added to the model. Thus, the model will add more infrastructure elements (transport infrastructure, technological progress), FDI, business services, and human capital. The study considers the influence of these factors on $\lambda1, \lambda2$.

To measure the capacity of means of transport, we use the density of vehicles (train), highways, and railways (Rail). The study uses the number of landline (tel) phone subscribers in the phone book to reflect information technology (IT) penetration into technology spillover during 2010 – 2019. In particular, foreign capital (FDI) is measured by the international share of total industrial output. The scale of business services includes financial *(fin)* and utility services *(UTI)*. Finally, the degree of human capital *(EDU)* is defined as the ratio of college students to the local population. Table 5 summarizes the statistical results of the interacting variables when expanding the model.

Similarly, each additional element will have interacted with W_1Tfp and W_2Tfp included in the analysis model. Regression is performed according to the FE-2SLS method. The results of the regression are presented in Table 6.

The estimation results show that the coefficients $\hat{\lambda}_1$ and $\hat{\lambda}_2$ are similar to the coefficient estimation results $\hat{\lambda}_1$ and $\hat{\lambda}_2$ of the base model (5) (column 2 of Table 2). Column 2 of Table 6 shows clear evidence that the interaction coefficient W_2Tfp × Hwy (0.046) has high statistical significance. It is implied that better highways will stimulate inter-regional spillovers. The coefficient of W_2Tfp × Rail is – 0.242, which is insignificant. Therefore, this result shows that the spillover between regions is mainly road transport. Column 4 shows that telephone infrastructure is found to influence interregional spillover positively. The interaction coefficient W_2Tfp × FDI (– 0.221) is statistically significant, indicating that the presence of foreign-owned firms negatively affects technology spillover both in the short and long term. This result seems to contradict the results of previous studies (Le & Pomfret, 2011; Nguyen & Nguyen, 2012). According to Le and Pomfret (2011) and

Table 5. *Descriptive Statistics of the Interacting Factors*

Variable	Mean	Std.	Min	Max
Large	5.724	1.174	– 2.293	11.724
County	6.382	0.885	– 0.830	10.383
Boder	6.493	0.726	2.494	11.193
Tran	0.053	0.184	0.000	1.000
Hwy	0.188	0.353	0.000	1.000
Rail	1.233	2.091	0.007	12.233
Phone	2.655	1.455	– 0.506	9.654
Fdi	0.154	0.174	0.006	0.853
Uti	1.222	1.622	0.007	12.221
Edu	2.647	1.247	– 0.505	7.647

Table 6. ***Socioeconomic Factors Affecting Technology Spillover***

	Regressor with Dependent Variable: *TFP*							
Variable	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
W_1Tfp	**0.330****	**0.311****	**0.375****	**0.452****	**0.338****	**0.371****	**0.381****	**0.410****
	(0.057)	(0.056)	(0.070)	(0.064)	(0.065)	(0.055)	(0.048)	(0.057)
W_2Tfp	**0.105****	**0.107****	**0.102**	**– 0.058**	**0.037**	**0.128***	**0.063**	**0.038**
	(0.052)	(0.048)	(0.071)	(0.047)	(0.056)	(0.066)	(0.055)	(0.065)
Interactions	*Tran*	*Hwy*	*Rail*	*Phone*	*Fdi*	*Fin*	*Uti*	*Edu*
W_1Tfp × factor	**– 0.031****	**– 0.032***	**– 0.188**	**– 0.119***	**– 0.221****	**0.008**	**0.015**	**– 0.010**
	(0.014)	(0.013)	(0.123)	(0.071)	(0.056)	(0.010)	(0.017)	(0.007)
W_2Tfp × factor	**– 0.035***	**0.046****	**– 0.242**	**0.129****	**– 0.337****	**0.030****	**0.037****	**0.023****
	(0.020)	(0.021)	(0.146)	(0.043)	(0.147)	(0.013)	(0.083)	(0.011)
N	**36420**	**36420**	**36420**	**36420**	**36420**	**36420**	**36420**	**36420**
R^2	**0.124**	**0.124**	**0.127**	**0.111**	**0.127**	**0.126**	**0.123**	**0.122**
$\hat{\sigma}_\mu$	**1.231**	**1.234**	**1.237**	**1.231**	**1.266**	**1.209**	**1.228**	**1.235**
$\hat{\sigma}_u$	**0.670**	**0.669**	**0.683**	**0.676**	**0.668**	**0.668**	**0.671**	**0.671**

Note. Standard errors in parentheses; Significance codes: '**' 0.05, '*' 0.10.

Nguyen and Nguyen (2012), if the share of FDI in the locality is high, it will make local enterprises more productive. Here, the study measures the spillover effect by spatial dependence of productivity at the firm level (λ1 and λ2). The results provide new evidence that the presence of FDI enterprises increases total productivity but reduces horizontal connectivity among neighboring firms. The results of this study support the findings obtained by Aitken and Harrison (1999) and Truong et al. (2015). In addition, the study also shows that the size of the financial sector (Fin) (column 6), services (UTI) (column 7), and human capital (Edu) (column 8) contribute positively to the inter-region spillover.

Conclusion and Implications

The study uses a spatial econometric model to evaluate the spillover effect of technology (measured by TFP at the enterprise level) and the determinants of domestic firm productivity. Using the spatial autoregression (SAR) model, research shows a technology spillover effect on domestic processing and manufacturing enterprises. We boldly recommend the necessary policies using the findings from extending the base model with interactive components.

First, the research results demonstrate that the OLS estimates of the influence of the determinants on technology spillover will be biased if the TFP variable depends on the geographical location. Using the spatial autoregression (SAR) model covering the whole spatial scale is appropriate to consider the determinants and evaluate technology spillover effects. This study has implications for further studies in determining the influence of spatial factors on technology spillover in provinces and regions of a country.

Second, positive technology spillovers can be enhanced through the promotion of large-cap and large-scale enterprise linkages. It is a group of firms with many potential and advantages in accessing, learning knowledge, and self-improvement techniques from the interaction process. However, the expectation of large-scale technology spillover effect may be unrealistic when domestic processing and manufacturing enterprises are primarily small and medium-sized.

Third, it is vital to prioritize the development of inter-regional transport infrastructure. Favorable transport infrastructure promotes technology spillover between businesses through the shift of factors of production. In addition, credit policy, administrative procedure reforms, and industrial services must be strong enough and suitable for all types of businesses to serve the needs of increasing investment capital.

Fourth, to shorten the technological gap between domestic enterprises, it is necessary to focus on developing R&D activities and combining learning and selective application of knowledge and technology from domestic and foreign enterprises to suitable actual conditions. At the same time, combining both technological innovation and technology diffusion makes resources more efficient. In particular, relevant ministries and sectors need to create a mechanism to allow or encourage businesses and individuals to learn and develop new technologies, and appropriate policies need to be in place to ensure the interests of new technology creators.

Limitations of the Study and Scope for Further Research

Most of the conclusions from the study provide new evidence of technology spillover in Vietnam, clarifying previous doubts. However, this study still has some unresolved questions. Firstly, the spillover from FDI activities to enterprise productivity is relatively low. Second, the current empirical model does not clarify whether internal or external factors can influence an enterprise's ability to generate and absorb technology. Better measurements of FDI or better experimental models may provide insights into these phenomena, and the authors of future studies can delve into these areas for future research.

Author's Contribution

Dr. Hai Minh Nguyen conceived the idea and developed qualitative and quantitative designs to undertake the empirical study. He extracted research papers with high repute, filtered these based on keywords, and generated concepts and codes relevant to the study design. The same was further transcripted and translated into English. The numerical computations were done by Dr. Hai Minh Nguyen using STATA 13.0. Dr. Nguyen wrote and edited the final manuscript.

Conflict of Interest

The author certifies that he has no affiliations with or involvement in any organization or entity with any financial or non-financial interest in the subject matter or materials discussed in this manuscript.

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