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International Journal of Economics and Business Research

ISSN online: 1756-9869 - ISSN print: 1756-9850
https://www.inderscience.com/ijebr

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Article History:

Received:	22 July 2023
Last revised:	14 September 2023
Accepted:	23 September 2023
Published online:	19 January 2024

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Abstract: After choosing the country to penetrate, foreign investors will decide the location for the operation. The decisions not only have to accommodate the institutional conditions that vary between home countries and host countries but also within the chosen host country. Based on theories of location choice, we analysed the impact of the determinants on the location choice of the high technology investors that used the institutional variables and traditional factors at the provincial level in Vietnam. The research used the methodology of spatial regression panel data and agglomeration effect in 63 provinces in Vietnam from 2007 to 2020. The results show that the institutional variables have a significant meaning on high-tech foreign direct investment (FDI), and the traditional factors affect the location choice of the investors.

Keywords: high-technology FDI; sub-national institution; location choice; Vietnam.

Reference to this paper should be made as follows: Hang, P.T.T., Tuong Anh, N.T. and Quang, P.D. (2024) 'The sub-national institution in an emerging country and the location choice of high technology investment: evidence from Vietnam', *Int. J. Economics and Business Research*, Vol. 27, No. 1, pp.151–174.

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1 Introduction

In the COVID-19 pandemic and the US-China trade war, the FDI inflow tends to increase due to the stable political and economic situation and the efficient pandemic treatment policies. However, before 2018, Vietnam massively attracted FDI in quantity without concern about quality. As a result, several projects involving FDI enterprises have had severe consequences for the environment, such as Formosa Ha Tinh, Vedan Dong Nai, Meusheng Textiles Ba Ria Vung Tau, Sonadezi Long Thanh, Pangun Neotex Textiles and Dyeing, Miwon, … The projects from foreign investors that pollute the environment are mostly related to the textile, footwear, and food industries, in which enterprises use low technology and take advantage of Vietnam's cheap labour. By 2019, the Government's Resolution No. 50-NQ/TW2019, dated 20th August 2019, clearly indicated that Vietnam should restrict low-technology FDI, causing environmental pollution, but focus on attracting high-technology, good-quality FDI.

Vietnam is a country with the power concentrated on the government, and the government decentralises the function down to the sub-national authorities. Nevertheless, there is a change in the enforcement among the sub-national authorities due to normative or cognitive aspects of institutions. Moreover, Vietnam has reformed the institutions and regulations through decentralisation by streamlining the state apparatus. The variety of implementation in local provinces depends on the local mechanism, although the primary policy in Vietnam is administrative decentralisation.

The Vietnamese Government is highly interested in upgrading the business environment, mainly through administrative reform. According to the 11th National Party Congress Resolution, administrative reform was identified as one of the breakthroughs in the country's socio-economic development strategy for 2011–2020. The government issued Resolution No. 30c/NQ-CP dated 8 November 2011, on the master program related to state administrative reform from 2011–2020.

The Government's Resolution No. 35/NQ-CP on supporting and developing businesses until 2020 was issued in mid-2016 for the government's entire term. Resolution 35 stated that the views, orientations, principles, and critical measures were identified to support and develop businesses. A cross-cutting point of Resolution 35 is to focus on developing the private economy, "private enterprises are the driving force to improve the competitiveness and autonomy of the economy."

Resolution 2 NQ/CP dated 2019 has set three-year goals, from 2019 to 2021, focusing on improving the business environment index, specialised inspection, business conditions, digital transformation, and start-up ecosystem.

According to Meyer and Nguyen (2005), in transiting countries, cumbersome and rigid administrative procedures can make it difficult for foreign investors in the process of implementation and operation, which can trigger bribery and corruption to take place. On the contrary, a 'friendly' government system will reduce difficulties and transaction costs of foreign companies, encouraging more investment in the province.

Therefore, the local business environment has an important role in attracting foreign investment. A locality with a high quality of economic management and a favourable business environment will tend to attract foreign investors more than a province with troublesome governance. The question is how the government could improve institutional policies to attract high-technology FDI to the provinces in Vietnam. Why are there apparent differences in the quantity of high-technology FDI projects within 63 regions in Vietnam? The article researches the factors affecting high-technology FDI using institutional variables and traditional factors. The research used the methodology of spatial regression panel data and agglomeration effect in 63 provinces in Vietnam from 2007 to 2020.

The remaining of the paper is structured as follows. Section 2 offers our literature review and theoretical framework on institutions and foreign investment strategies. Section 3 presents our empirical methodology. Section 4 shows the research results, and Section 5 highlights the implications for developing the institutional perspective of strategy.

2 Literature review and hypothesis development

2.1 Literature review

The business environment can be conceptualised as consisting of two layers. The layer closest to the organisation is the 'task' environment (industry environment), whose sectors of competitors, suppliers, and customers have direct transactions with the organisation. The task environment directly affects the organisation and is affected by the organisation. The 'outer' layer is the general environment (macro-environment) that contains the socio-cultural, political/legal, economic, and technological forces with which the organisation has a comparatively indirect relationship. This research only concentrates on the macro environment, including institutional and economic climate.

In empirical studies, the authors often define the determinants affecting investors' location choices based on economic efficiency, called 'traditional factors'. The enterprises will divide the company's activity into revenue and profit and identify the factors that impact the two components. The factors related to resources include the market size, the natural resources, the cost and quality of labour, and infrastructure (Meyer and Nguyen, 2005; Wu et al., 2019; Zeng et al., 2020). Danciu and Strat (2014) study the factors affecting FDI in the manufacturing sector, a high-tech FDI field. Influential factors include infrastructure, agglomeration effect, labour cost, cost, knowledge, and market factors.

Recently, empirical research about the institution proposes that institutional factors have impacted the choice of foreign investors. Othman (2022) states that the regulatory

quality index outperforms all other governance factors in attracting foreign direct investment (FDI) inflows into the Arab region. Dornean et al. (2022) analyse where FDIs are influenced by the business climate of the host country, including the institutional and the sustainable indicators, and summarise that the developed countries are more affected by the sustainable factors than the emerging countries. Song et al. (2020) states that the partial institutional quality improvement of a special economic zone in China is the crucial mechanism in the location of foreign investment. Liu et al. (2018) construct a new set of comprehensive indexes of governance quality, comparable between different years (2001–2015) in China's provincial regions, which focuses on a multi-dimensional governance perspective of "horizontal allocation of power, governance capacity, supervising power." Choi et al. (2015) uses industrial parks with low tax rates and efficient government apparatus; the level of marketisation (marketing), effective registration of property ownership; environmental protection; political freedom, which has practical impacts on business operations and productivity. Tebaldi (2011) uses a simple theoretical model to show that high-tech exports are related to human capital, technology, quality of institutions, and the degree of economy. Athreye (2004) states that large foreign investors are attracted by human capital and technical institutions in the host country. Malesky et al. (2014) summarises that transparency of regulatory information and private sector development services such as trade fairs and technology training have strongly impacted FDI.

In Vietnam, PCI indexes are regularly used in research of the institution. Many authors used PCI in their research. Dinh (2009) leads to the result that transparency and access to information have significant meaning in joining the FDI market. Nguyen et al. (2014) states that the region's institutional environment, especially the enforcement institution, includes transparency, corruption, and access to the land, which is essential in attracting FDI investors. The supporting institution includes labour and support of the firms, and the pioneering dynamics have less significance. Esiyok and Ugur (2015) says that PCI has a less effective, minor impact. Nguyen and Nguyen (2007) investigates the effect of the factors attracting FDI province level from 1988 to 2006. This study shows that PCI does not impact investors from different countries. Anh et al. (2007) uses PCI 2005 and PCI 2006 (the period is too short) with the four indexes: transparency, the bias of public sectors, proactivity, and legal institution; the result shows that the complex infrastructures attract registered FDI, institution attracts the realised FDI. Malesky (2007) summarises that the rate of realised FDI related closely to PCI, the average profit of joint venture companies strongly connected with the business environment. If the business environment is good, they will add more capital. The transparent and business support services index will influence FDI. The land access and security of tenure will affect the realised FDI. Ngo et al. (2018) summarises that general PCI and business support services have significant impacts while other indexes have no meaning. Hoa et al. (2021) found out that the business support and market entry cost, the component indexes of PCI were positive with the investment flow, and the investors only focused on a few essential components in PCI.

Regarding the definition of high-technology FDI enterprises, the research still uses the definition of FDI and focuses on the final product's foreign investors manufacture. FDI enterprises have the product which is in the range of high technology that OECD classified, it will be called the high technology foreign investors. Some researchers also use the definition of OECD to apply to list high-technology FDIs, such as Marasco (2002) and Liu and Zou (2008).

OECD (2011) clarifies manufacturing industries into categories based on R&D intensities. High-technology industries: aircraft and spacecraft, pharmaceuticals, office, accounting and computing machinery, radio, TV, communications equipment, medical, precision, and optical instruments. Medium-high-technology industries: electrical machinery and apparatus, motor vehicles, trailers and semi-trailers, chemicals excluding pharmaceuticals, railroad equipment, transport equipment, machinery, and equipment. The high technology includes high and medium-high technology.

In Vietnam, we have the High Technology Law, 2008, which states that: high technology is a technology with a high content of scientific research and technological development, which is integrated from modern scientific and technological achievements, creating products with quality, outstanding features, and high added value and plays a leading decisive role in productivity, product quality, and has an essential impact on socio-economic development.

Nevertheless, the General Statistics Office (GSO) and Minister of Plan and Investment (MPI) data have not been collected according to the high technology law. As a result, we still use the definition of high technology of OECD as the standard for this research.

Regarding the methodology, the research used the spatial regression panel data in foreign countries can be listed such as Esiyok and Ugur (2015), Hamzalouh et al. (2017), Fonseca and Llamosa-Rosas (2018), Wang et al. (2020), Asrirawan et al. (2021) and Zongo and Diarra (2022). These studies mainly analyse the determinants of FDI attraction in the manufacturing sector at the regional level. As for in Vietnam, the spatial panel data has been used in some studies such as Vinh et al. (2020), Do et al. (2021), Nguyen and Nguyen (2020) and Le and Nguyen (2017). Similarly, these researches also study the factors that affect FDI and the poverty distribution at Vietnam's provincial level. The study used the spatial panel data in Vietnam is still sufficient, and we could enrich the empirical studies with this new methodology.

This research makes the following contribution. Firstly, there are many empirical studies about determinants of FDI attraction at the regional level in and out of Vietnam. Nevertheless, there needs to be more research on high technology FDI. Secondly, the research used PCI in the study only in 2018, and the author will update the empirical study for a long time, from 2007 to 2020. Thirdly, there needs to be more research on the relationship between institutions and high technology FDI by spatial panel data in Vietnam. As a result, this empirical study could contribute to the research on the location choice of high technology FDI by spatial panel data in Vietnam.

2.2 Theoretical framework about impact of institutions on the location choice of firm

The recent theoretical works have integrated institutional perspectives with business strategies and global business analysis by applying theoretical advances in institutional economics and sociology. The legal framework and institutions are pivotal concerns to businesses operating in emerging markets, especially when unfamiliar with the local environment. Hoskisson et al. (2000) suggest that the institutional perspective is one of three lines of theorising, which can be expected to yield new insight into business in emerging economies.

Institutions contribute to locational advantages, one of three parts of the ownership-location-internalisation (OLI) paradigm explaining the key factors that resulted in FDI. Institutions play a crucial part in locations, one of three OLI paradigm pillars (Dunning, 1980, 1993). The theory states that the origin of FDI starts from three factors: O (ownership) includes tangible and intangible assets that are unique to firms; L (location) that is profitable to the firms to combine advantages (natural endowment, cultural and political factors, institutions, …) in the host country with the home country, I (internalisation) known as entry mode for firms to exploit the advantages fully. Nevertheless, Dunning (1998) called the location within countries (provincial level) a 'neglected factor of the OLI paradigm' because the international business literature only concentrates on whole countries. As a result, location is an essential factor in the investment flow and the institution factor is the new factor that impact to the location choice of FDI in the provincial level.

The theory we would like to focus intensely is the agglomeration effect theory in this research. The first agglomeration effect theory is developed by Marshall and Marshall (1920), in which the theory shows that firms experience external economies and increasing returns when they agglomerate together in close geographical proximity. He states three reasons for the clustering of the firms in the same industry: first, it supplies the potential market for the human resource with the high qualification; second, it affiliates for the firms to save the transportation cost when they are located near the suppliers or consumers; thirdly, the firms could receive the technology spillover when clustering together. For example, the firms in Silicon Valley are in a region that benefits from innovation. Some empirical studies about the Vietnam market used the agglomeration effect can be listed by Meyer and Nguyen (2005), Dinh (2009) and Esiyok and Ugur (2015). This theory can explain why many companies are clustered in one region while very few are in another region within one country.

Vietnam is a transition economy, where formal and informal institutions can significantly influence the location choice of foreign investors. Although the law power in Vietnam is concentrated on the central government, there are discrepancies between official policy and local implementation. The formal institution such as access land, a limited resource in Vietnam and have strict rules about the Land Laws of Vietnam, which do not allow the foreigner to possess the land asset or transparency about registration, enumerate the documents in the official units in the different provinces can result in unexpected costs. These matters can be a cumbersome to prevent the high technology foreign investors from locating in one region.

In the case of Vietnam, an emerging country, the high technology enterprises, when choosing a specific location, will be affected by the traditional determinants such as labour, education, market, and infrastructure. In this research, we would like to focus on the non-traditional factors as institutions (including PCI, access land, and transparency).

3 Methodology

3.1 Model specification

We used Global Moral's I to check for spatial interdependencies between the high technology FDI and the business environment, especially in the institutional environment at the provincial level in Vietnam. Moral's I can be asked to test if data has a spatial

relationship in economic analysis. Firstly, using the non-spatial panel models, baseline results can be generated as pooled OLS models and fixed effect models. Such baseline results are initial evidence of the relationship between high technology FDI and the business environment. Then, to expand these baseline results, the spatial models are estimated. Our analysis used SDM, SAR, and SEM to match the theoretical model closely.

SDM is the model that studies the spatial weight of the dependent Y and the independent X. The model is expressed in matrix form as follows:

$$Y_{it} = \rho WY_{it} + \alpha_t i_N + X_{it}\beta + WX_{it}\theta + \varepsilon_{it}$$

- Y_{it}: The vector of the dependent variable of nxT observations, from the 1st observation to the n observation in time t = 1, 2, …, T.
- W: Spatial matrix of n observations.
- WY_{it}: Spatially lagged variable of the dependent variable at time t = 1, 2, …, T.
- ρ: Regression coefficient of lagged variable in space WYit.
- $\alpha_t i_N$: i_N is an identity matrix associated with the constant term parameter α_i.
- X_{it}: Matrix (nxk) of values of independent variables at time t, including free coefficients.
- β: Regression coefficient vector of independent variables in X.
- θ: Exogenous interaction effects of neighbouring regions of the explanatory variable WX_{it} ($WX_{it}\theta$) exogenous interaction.
- ε_{it}: Vector (nxT) errors at time t.

Durbin spatial regression model (SDM), including SAR, SEM, and SLX models, can give unbiased estimation results even if the data structure is SAR, SEM, or SLX model. This SDM model includes spatially weighted explanatory variables, and the error vector does not include the spatial autocorrelation error component ($Wu_{it} = 0$). SDM allows consideration of marginal effects, including endogenous and exogenous interactions. SDM model can be simplified to become the SAR, SEM, and SLX models. The differences between these models are illustrated in Figure A1 in Appendix.

3.1.1 Spatial weight matrix

In our research, we use a first-order contiguous spatial weight matrix. Coughlin and Segev (2000) say that a locality i that shares a boundary with locality j ($i \neq j$) is spatially correlated. Then, each element of the spatial weight matrix is determined by:

$$W_{ij} = \begin{cases} 1 & \text{i, j share border} \\ 0 & \text{i, j not share border} \end{cases}$$

The summary result of the contiguous spatial of 63 provinces in Vietnam includes 270 links in which one province will be contiguous with at least two other provinces, and the maximum number of links will be one province is contiguous with eighth other provinces. The average degree of connectivity between provinces is 4.2, meaning that, on

average, a province will be adjacent to about four other provinces (see Appendix Table A1).

3.2 Data description

3.2.1 Dependent variable

- *lnHTFDI (high-tech FDI):* The data are collected from Minister of Planning and Investment (MPI). We use the natural logarithm of the new registered high-technology FDI (million dollars).

3.2.2 Independent variables

- *PCI* consists of ten component indicators with different weights, namely:
  1 market's entry cost
  2 land access and security of tenure
  3 transparency and access to information
  4 time costs and regulatory compliance
  5 informal charges
  6 policy bias
  7 the proactivity of provincial leadership
  8 business support services
  9 labour training
  10 law and order.

  The data are taken from the PCI report annually. The role of the PCI is hypothesised to be positive. Because the PCI indicator is published one year later so, we use PCI_lag1 to show the latency of institutional variables. And this method is used in Nguyen et al. (2014), Meyer and Nguyen (2005) and Dinh (2009) and shows the result is positive.
- *Land access* symbols Aland, which is a component of the PCI index. This index measures two aspects of enterprises' land problems: whether it is easy to access land and whether companies feel secure and assured of stability when acquiring land. The role of land access is hypothesised to be positive such as Ngo et al. (2018).
- *Transparency* symbols Trans. This index measures the ability of enterprises to access provincial documents or provincial plans to serve business activities. The role of transparency is hypothesised to be positive such as Ngo et al. (2018).
- *LPI:* Logistics performance index, measured by the World Bank, used to appreciate the advantage of trade logistics in each country. This index is an essential criterion for investors to decide the location to enter. The role of the LPI is hypothesised to be positive.

Table 1 Data summary

Number	*Variables*	*Definition*	*Symbol*	*Expected directions*	*Source*
	Dependent variable	Natural logarithm of HTFDI (million dollars)	LnHTFDI		MPI
		Explanatory variables			
1	PCI	Provincial competitiveness index measures economic governance at province level	PCI	+	pcivietnam.vn
2	Land access	This index measures two aspects of enterprises' land problems: whether it is easy to access land and whether companies feel secure and assured of stability when acquiring land	Aland	+	pcivietnam.vn
3	Transparency	The ability of enterprises to access provincial documents or provincial plans to serve business activities	Trans	+	pcivietnam.vn
4	LPI	Logistics performance index	LPI	+	World Bank
5	Education	The measure of education in the methodology is the number of school years received by citizens who are 15 years old or older	Ledu	+	Provincial Statistical Yearbook from 2007–2020
6	Real wage	Measured by the actual average monthly compensation of workers in each province	Rwage	+	Provincial Statistical Yearbook from 2007–2020
7	Ledu x Rwage	Interaction index between labour rate and actual salary/month by province	Ledu x Rwage	+	Provincial Statistical Yearbook from 2007–2020
8	GRDP	Natural logarithm of Gross regional domestic product	lnGRDP	+	Provincial Statistical Yearbook from 2007–2020

Source: Summarised by authors

- *Ledu x Rwage:* Interaction index between labour rate and actual salary/month by province. Education is a critical factor that impacts the amount of FDI at the national and provincial levels. The measure of education in the methodology is the number of school years received by citizens who are 15 years old or older. In our econometric model, actual wage rates are measured by the real average monthly compensation of workers in each province. The data are taken from the annual comprehensive enterprise survey conducted by the GSO. The role of the Ledu x Rwage is hypothesised to be positive (Le and Nguyen, 2017).
- *lnGRDP:* This variable represents the province's economic conditions and market demand potential. To measure the market size, the author uses the natural logarithm of gross regional domestic product as given by Hoang and Goujon (2014), Esiyok and Ugur (2017) and Hoang et al. (2020) … as well as many other scholars doing research in this field. The expected effect is positive.

4 Results and discussion

4.1 The observed variables statistical description

To reject the multi-collinearity phenomenon in the research model, we test variance inflation factor (VIF) on independent variables. VIF of independent variables is bigger than 10, which means the multi-collinearity phenomenon exists. Table 3 shows the value of VIF on explainable variables.

Table 2 The descriptive statistics result

Variable	*Obs.*	*Mean*	*Std. dev.*	*Min*	*Max*
HTFDI	882	82.27	380.60	0.00	6,418.43
lnHTFDI	882	7.08	8.70	0.00	22.58
PCI_lag1	882	58.57	6.08	36.07	77.61
Aland	882	6.36	0.82	3.04	8.84
Trans	882	6.03	0.72	2.24	8.85
LPI	882	50.86	7.64	39.00	64.00
Ledu	882	16.14	7.12	4.40	48.50
RWage	882	2,217.68	1,113.91	445.55	7,294.38
LeduRWage	882	40,235.59	39,382.12	4,387.14	302,240
lnGRDP	882	10.23	0.97	7.62	13.81

Source: Calculated by the author

From Table 3, we can see that the VIFs of the chosen variables are smaller than 10. As a result, the multi-collinearity is presumed not to be an issue that affects our results.

Before using spatial econometric models to estimate the effects of variables, the first step is to check whether there is a spatial effect in the data by determining spatial autocorrelation using graphical representations (maps) and statistical tests (Floch and Le Saout, 2018). Date statistics were introduced (Moran, 1948) and popularised through spatial autocorrelation analysis (Cliff and Ord, 1973).

Table 3 VIFs on independent variables

Variable	*VIF*	*SQRT_VIF*	*Tolerance*	*R-squared*
PCI_lag1	1.69	1.30	0.5909	0.4091
Aland	1.19	1.09	0.8395	0.1605
Trans	1.26	1.12	0.7965	0.2035
LPI	1.24	1.11	0.8085	0.1915
LeduRWage	2.34	1.53	0.4265	0.5735
lnGRDP	2.27	1.51	0.4398	0.5602
Mean VIF	1.67			

Source: Calculated by the author

The spatial autocorrelation (Global Moran's I) tool simultaneously measures spatial autocorrelation based on feature locations and feature values. Given a set of features and an associated attribute, it evaluates whether the pattern expressed is clustered, dispersed, or random. The tool calculates Moran's I Index value and a z-score and p-value to assess the significance of that index. P-values are numerical approximations of the area under the curve for a known distribution, limited by the test statistic.

Table 4 Global Moran I statistics for log (HTFDI)

Year	*Moran's I*	*Mean*	*SD*	*z-value*	*p-value*
2007	0.33036	–0.0143	0.088	3.9018	0.001
2008	0.43690	–0.018	0.087	5.1793	0.001
2009	0.16176	–0.0183	0.087	2.0588	0.029
2010	0.31676	–0.0183	0.084	3.972	0.002
2011	0.36688	–0.0129	0.088	4.2859	0.001
2012	0.39303	–0.0129	0.086	4.719	0.001
2013	0.41049	–0.0172	0.084	5.0418	0.001
2014	0.41071	–0.0115	0.087	4.8459	0.001
2015	0.45351	–0.0136	0.090	5.1557	0.001
2016	0.48861	–0.0059	0.088	5.5832	0.001
2017	0.40211	–0.0155	0.089	4.6799	0.001
2018	0.43633	–0.0141	0.089	5.0139	0.001
2019	0.43669	–0.0204	0.086	5.2734	0.001
2020	0.35879	–0.0189	0.088	4.2713	0.001

Source: Calculated by the author

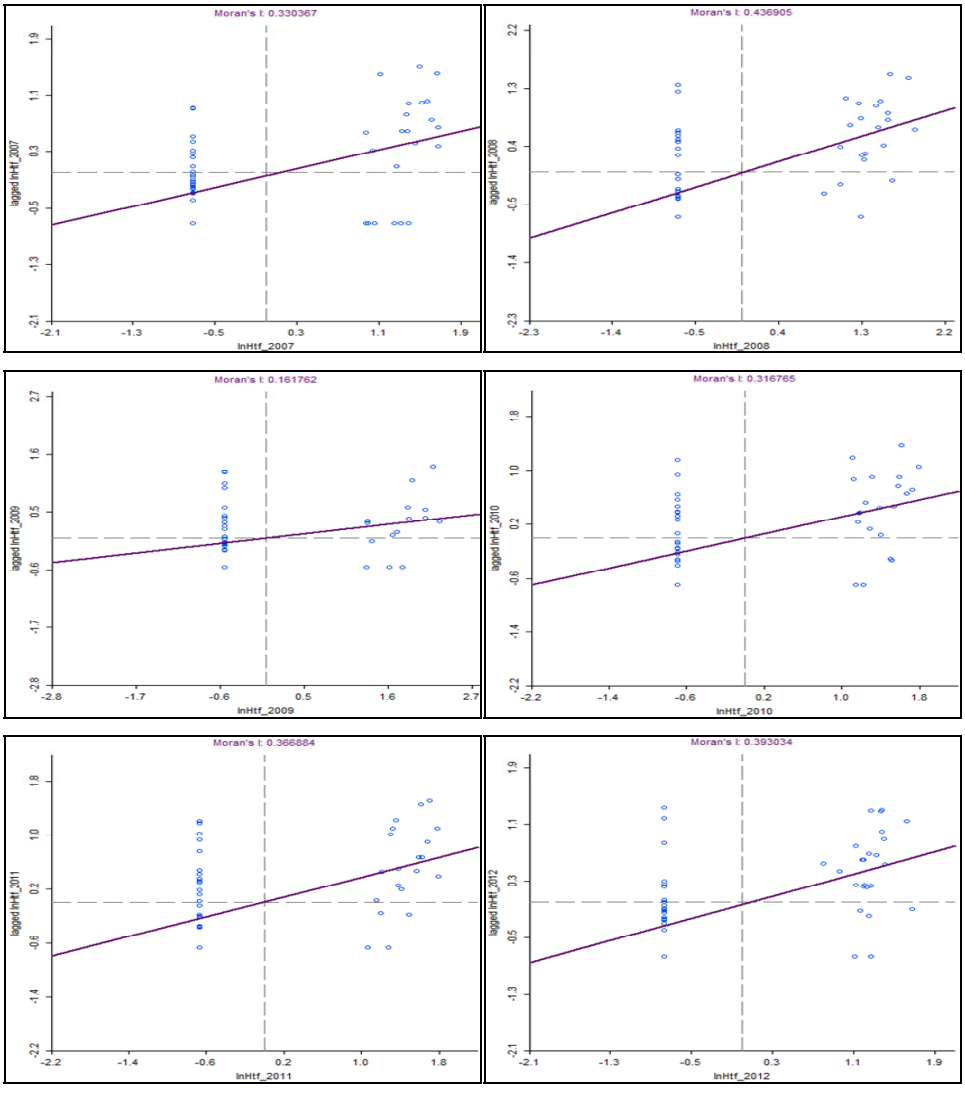
We can see that the p-value < 0.05 and the z-value is positive, so we reject the null hypothesis. The dataset's high and low values spatial distribution is more spatially clustered than expected. The HTFDI is not randomly distributed but according to a certain spatial distribution pattern. Thus, the study must apply the spatial econometric model to find the spatial autocorrelation coefficient.

The Moran's I is further visualised by a Moran scatter plot which shows the relationship between the standardised variable (horizontal axis) and its own spatial lagged

variable with a standardised weight matrix (vertical axis). The slope of the linear line fitting the scattered data point is Moran's I coefficient.

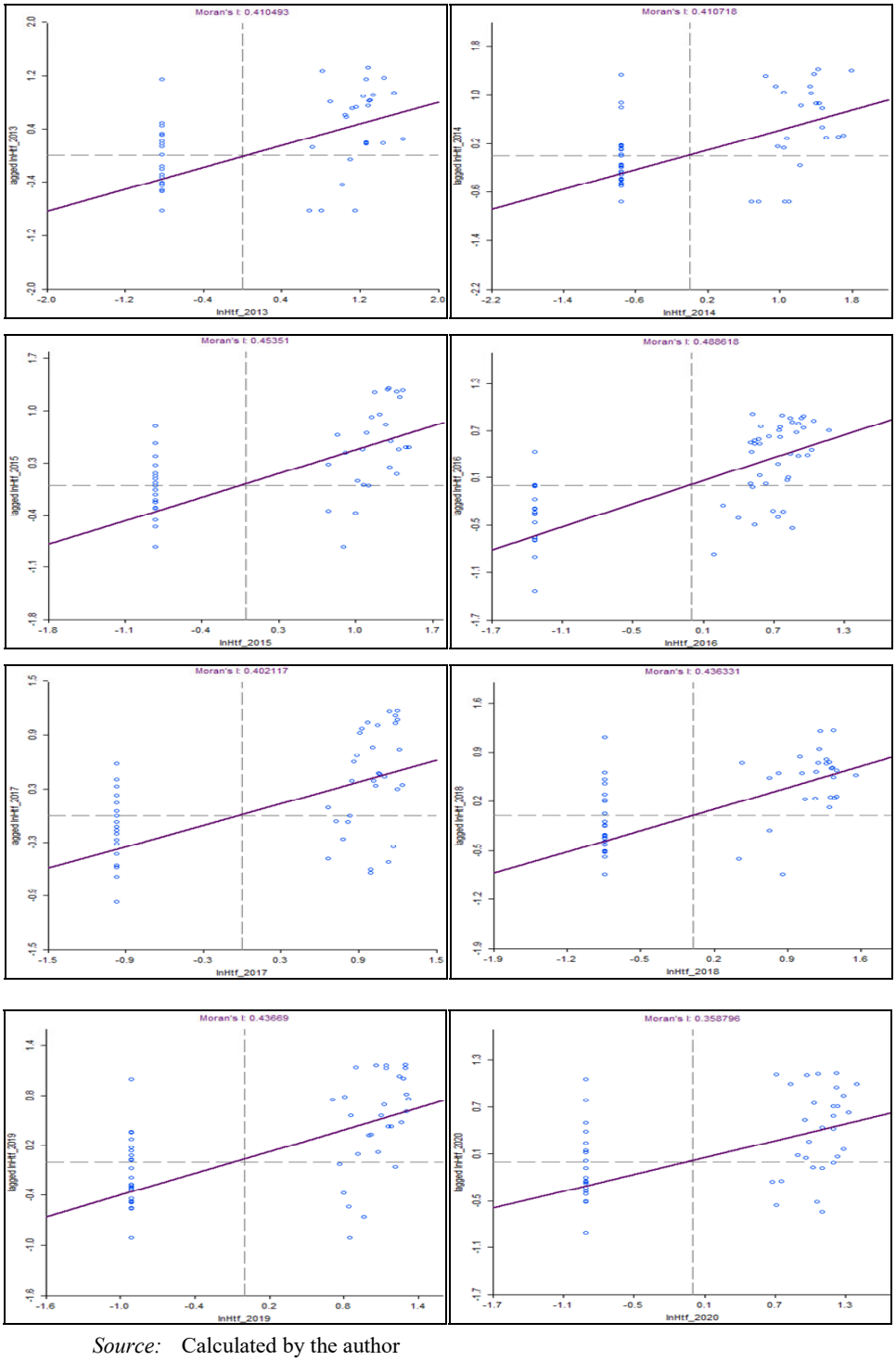
When Moran's I coefficient is positive, it is represented by a straight line with a positive slope that passes through the first and third quadrants. When Moran's I coefficient is negative, the fitted straight line with a negative slope goes through the second and fourth quadrants.

Figure 1 Moran scatter plot (see online version for colours)



Source: Calculated by the author

Figure 1 Moran scatter plot (see online version for colours)



Source: Calculated by the author

4.2 Model selection test

The non-spatial model is below:

$$\ln \mathrm{HTFDI}_{it} = \beta_1 \mathrm{PCI\_lagl}_{it} + \beta_2 \mathrm{Aland}_{it} + \beta_3 \mathrm{Trans}_{it} + \beta_4 \mathrm{LPI}_{it} + \beta_5 \mathrm{LEduRWage}_{it} + \beta_6 \ln \mathrm{GRDP}_{it} + \alpha_i + v_t + \varepsilon_{it}$$

The tests of non-spatial models are made and the results are illustrated in Appendix.

The spatial model we used to test include SDM, SAC, SAR and SEM. The spatial models are specified as below:

- Spatial Durbin model (SDM):

$$\ln \mathrm{HTFDI}_{it} = \rho \mathrm{W}_{ij} \ln \mathrm{HTFDI}_{jt} + \beta_1 \mathrm{PCI\_lagl}_{it} + \beta_2 \mathrm{Aland}_{it} + \beta_3 \mathrm{Trans}_{it} + \beta_4 \mathrm{LPI}_{it} + \beta_5 \mathrm{LEduRWage}_{it} + \beta_6 \ln \mathrm{GRDP}_{it} + \theta_1 \mathrm{W}_{ij} \mathrm{PCI\_lagl}_{jt} + \theta_2 \mathrm{W}_{ij} \mathrm{Aland}_{it} + \theta_3 \mathrm{W}_{ij} \mathrm{Trans}_{jt} + \theta_4 \mathrm{W}_{ij} \mathrm{LPI}_{jt} + \theta_5 \mathrm{W}_{ij} \mathrm{LEduWage}_{it} + \theta_6 \mathrm{W}_{ij} \ln \mathrm{GRDP}_{jt} + \alpha_i \mathrm{i}_N + \varepsilon_{it}$$

- Spatial autoregressive combined model (SAC):

$$\ln \mathrm{HTFDI}_{it} = \rho \mathrm{W}_{ij} \ln \mathrm{HTFDI}_{jt} + \beta_1 \mathrm{PCI\_lagl}_{it} + \beta_2 \mathrm{Aland}_{it} + \beta_3 \mathrm{Trans}_{it} + \beta_4 \mathrm{LPI}_{it} + \beta_5 \mathrm{LEduRWage}_{it} + \beta_6 \ln \mathrm{GRDP}_{it} + \alpha_i \mathrm{i}_N + \mu_{it}$$

$$\mu_{it} = \lambda \mathrm{W}_{ij} \mu_{jt} + \varepsilon_{it}$$

- Spatial autoregressive model/spatial lag model (SAR):

$$\ln \mathrm{HTFDI}_{it} = \rho \mathrm{W}_{ij} \ln \mathrm{HTFDI}_{jt} + \beta_1 \mathrm{PCI\_lagl}_{it} + \beta_2 \mathrm{Aland}_{it} + \beta_3 \mathrm{Trans}_{it} + \beta_4 \mathrm{LPI}_{it} + \beta_5 \mathrm{LEduRWage}_{it} + \beta_6 \ln \mathrm{GRDP}_{it} + \alpha_i \mathrm{i}_N + \varepsilon_{it}$$

- Spatial error model (SEM):

$$\ln \mathrm{HTFDI}_{it} = \beta_1 \mathrm{PCI\_lagl}_{it} + \beta_2 \mathrm{Aland}_{it} + \beta_3 \mathrm{Trans}_{it} + \beta_4 \mathrm{LPI}_{it} + \beta_5 \mathrm{LEduRWage}_{it} + \beta_6 \ln \mathrm{GRDP}_{it} + \alpha_i \mathrm{i}_N + \mu_{it}$$

$$\mu_{it} = \lambda \mathrm{W}_{ij} \mu_j + \varepsilon_{it}$$

Firstly, we test the result by the non-spatial models and by the Larang test to check the suitable model. The result of LR test on time period fixed effect is 45.80 with p-value = 0.000, and the LR test result on spatial fixed effect is 531.09 with p-value = 0.00, that lower than 1%. As a result, the time period fixed effects model is strongly rejected. In this article, the spatial fixed effects model should be used. The LM test determines whether to choose a spatial model or a traditional model; from the results of Moran's I and the LR test for the spatial model, it can be seen that the spatial regression model is better suited to this data (see Appendix Table A3).

The spatial regression model used in the study includes four models: SDM, SAC, and SAR, SEM. Test whether the SDM model can be simplified to SAR or SEM. Testing LR for SAR and SEM, we have the results to reject two models, SAR and SEM. So, the remaining two models are SAC, and SDM. The test relies on a smaller AIC, so choose SDM. Use the Hausman test to choose Re or Fe. We have a suitable model, which is SDM FE. We have the results of SDM Fixed effect as showed in Table 5.

Table 5 SDM fixed effect model estimation results

lnHTFDI	*Coef.*	*Robust std. error*	*z*	*P > |z|*	*[95% conf. interval]*	
			Main			
PCI_lag1	0.123	0.0575	2.14	0.032**	0.0103	0.236
Aland	0.697	0.3411	2.04	0.041**	0.0285	1.365
Trans	–0.023	0.3768	–0.06	0.951	–0.761	0.715
LPI	0	(Omitted)	.	.	.	.
Ledu	0.202	0.0853	2.37	0.018**	0.035	0.369
Rwage	0.0017	0.00086	2.08	0.038**	0.0001	0.0034
LeduRwage	–0.00003	0.000022	–1.34	0.181	–0.00007	0.0000142
lnGRDP	1.6373	0.414	3.95	0.000***	0.8246	2.4500
			Wx			
PCI_lag1	–0.0461	0.1065	–0.43	0.665	–0.2549	0.162
Aland	–0.7091	0.6143	–1.15	0.248	–1.9131	0.4949
Trans	–0.6471	0.7421	–0.87	0.383	–2.1016	0.807
LPI	0	(Omitted)	.	.	.	.
Ledu	0.5106	0.1514	3.37	0.001***	0.21386	0.807
Rwage	–0.0010	0.0012	–0.83	0.407	–0.0033	0.0013
LeduRwage	0.000019	0.000041	0.46	0.643	–0.0000	0.000098
lnGRDP	3.218	0.718	4.48	0.000***	1.8113	4.626
			Spatial			
rho	0.1657	0.042	3.9	0.000***	0.0824	0.2489
			Variance			
Sigma2_e	37.200	1.776	20.94	0.000***	33.7183	40.68

Notes: *p < 0.10; **p < 0.05; ***p < 0.01.

Source: Calculated by the author

Table 6 The direct effect, indirect effect, the total effect from SDM RE model

	LR_Direct	*LR_Indirect*	*Total LR*
PCI_lag1	0.0831864**	–0.0454001	0.0377862
Aland	0.8314029**	–0.6784782	0.1529246
Trans	0.257966	0.1179432	0.37591
LPI	0.0997806	0.0305411	0.13032
Ledu	0.0630836**	0.2559596***	0.31904
Rwage	0.0006127**	–0.0005162	0.0000965
LeduRwage	–0.00000971	0.00000862	–0.0000011
lnGRDP	0.1349806***	1.102619***	1.237600

Notes: *p < 0.10; **p < 0.05; ***p < 0.01.

Source: Calculated by the author

And then, we test to measure the impact of the direct effect, indirect effect, and total effect of the model, as shown in Table 6.

4.3 Discussion

4.3.1 Direct effect

4.3.1.1 The institution variable

The result shows that the institutional determinants are significant to the high-technology foreign investors. In case of the constant other conditions, if PCI index increase 1%, high technology FDI into the province will increase 8.3%. This result is suitable for our expectations. Because the PCI will be published one year later, as a result, the PCI of the previous year will affect the HTFDI amount of the current year. When the rise of the PCI point makes the high technology investment flow increase, the spillover effect will impact other provinces and increase foreign investment in the neighbouring regions.

Similarly, with the increase of 1% in the access land indicator, there is an increase in HTFDI by 83% in case of the constant other conditions. Access to land is an essential factor for foreign businesses before investing in Vietnam provinces. Because regulations on foreign ownership of land are still quite strict in Vietnam (according to the 2013 Land Law, foreigners are not allowed to own land in Vietnam), the regulations on lease term or form of lease, land rental cost is the first issue affecting whether to invest in that area or not?

Transparency measures the accessibility of development policies and plans relevant to business operations, their widespread availability and predictability of implementation, and transparency as the activity of local websites. However, for HTFDI enterprises, transparency has no effect because they need to learn how to use their power to access information and exploit the lack of transparency to make their investment opportunities.

4.3.1.2 The education and wage variable

The quality of human resources has a positive impact on attracting high-technology FDI. If the quality of education increases by 1%, the FDI in that province will increase by 6.3%, in other factors will remain constant;

Real salary variable has a positive impact on FDI attraction to high technology FDI, similarly, in the condition that other factors remain constant, if the salary increases by 1%, the FDN of that province will increase by 0.06%.

The estimation result of interaction variable (Ledu x Rwage variable) is negative in the spatial model and is not have meanings. This finding is in line with FDI across Vietnam provinces by Pham (2002), Nguyen and Nguyen (2007), Malesky (2007) and Esiyok and Ugur (2017). Coughin and Segeve (2000) and Gamboa (2013) researched the case of Chinese and Russian and found that wage or labour costs negatively affect FDI, as we found in the case of Vietnam provinces. The wage often negatively impacts foreign investment, especially for seeking resources investors. The opposite interaction of education and wage reveals that the investors could not accept an increased labour cost although workers' education is upgraded.

4.3.1.3 The market variable

The results show that the investors care about the consumption market of the chosen provinces. In the constant other variables, if the GRDP increases by 1%, the high-technology FDI will increase by 0.134%. That means a province with a potential

market will enable the high–technology FDI to enter. The close regions also benefit from increasing HTFDI in the areas with the potential market.

MNE engagement in high technology may be due to complex vertical integration motives. According to the typology, Baltagi et al. (2007) and Hoang and Goujon (2014) in high technology FDI is driven by complex vertical integration motives when the sign of the high technology FDI and GRDP in the spatial model is positive and significant. This phenomenon is called the region agglomeration effect. Coughlin and Segev (2000) pointed out that economic agglomeration can increase the number of FDI projects in the neighbouring regions when the economic relationship exceeds the provincial border. The foreign investors will tend to choose the region with the concentration of suppliers, other firms, natural resources, airports, seaports, and transportation to benefit from the positive spillover from the clustering.

4.3.2 Indirect effect

LPI has no meaning in this model. This is the general index for logistics in Vietnam to control for the infrastructure variable.

Labour quality has a spatial impact and positive meaning. If the quality of labour increases by 1%, the neighbouring provinces of HTFDI will increase by 25.5%, in other factors remain unchanged. It means that the labour quality not only impacts to the province itself but also impact to the neighbouring provinces, makes the HTFDI in these province increase.

Similarly, the market size has a spatial impact and a positive meaning. If the market size increases by 1%, the HTFDI in neighbouring provinces will also increase by 1.1%, in other factors remain unchanged.

The dependent variable HTFDI has a positive meaning (1%), proving that the HTFDI has a significant spatial impact. It is called the agglomeration effect. High-technology trends concentrate on clusters to improve their competitive advantage (Porter, 1990). Dinh (2009) studies on the influence of agglomeration effects on the choice of FDI location at the local level. Research on different countries Boudier-Bensabaa (2005) in Hungary, Meyer and Nguyen (2005) in Vietnam, Head and Ries (1996) and Cheng and Kwan (2000) in China – show that new foreign companies are likely to locate their headquarters near other foreign investors. In that way, they can use the experience and performance of previous investors as indicators of the underlying business environment in the location.

4.3.3 Total effect

The total effect is the sum of direct effects and indirect effects. The total effect is explained as a change in a specific factor in a locality that will affect the attraction of high-tech FDI inflows in that locality and neighbouring localities. The total effect of PCI lag 1 is 3.7%; as a result, the total effect reduces by 4.6% from the direct effect. The total effect of the access land factor is 15.2%, which means that if the access land point increase by 1%, the HTFDI will increase by 15.2%. The total effect of Ledu is 31 %; in the constant condition, if the Ledu increase by 1%, HTFDI will increase by 31%. This proves that the education quality is a crucial factor for the government to improve the quality of FDI inflow.

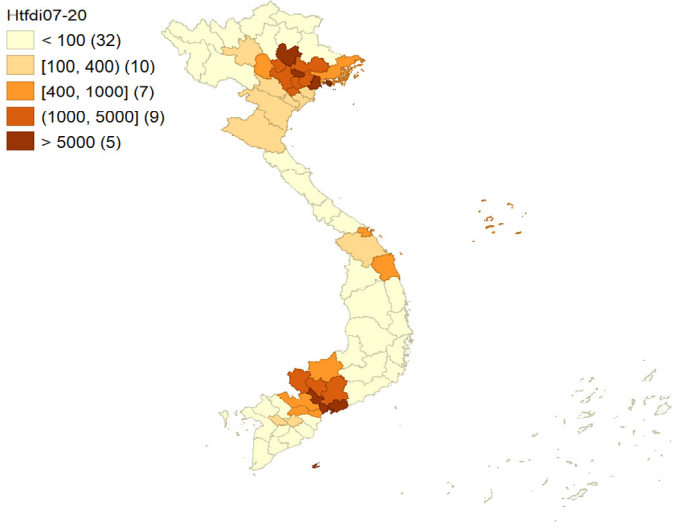
The total impact of the variable real wages is small, almost negligible, 0.0965%. Thus, the wage increase only significantly affects the attraction of high technology FDI to that province. What high-technology FDI enterprises care about is the quality of labour.

The total effect of HTFDI will increase by 1.23% when the GRDP increases by 1%. As a result, the market factor is not the outstanding factor to attract HTFDI. Actually, the high technology investors concentrate more on exporting the products to the outboard than serving for the domestic market.

4.3.4 Agglomeration effect

We can see in Table 5 that $\rho = 0.150$ means that the HTFDI has a positive spillover. The other provinces have benefited from the agglomeration effect. Moreover, GRDP has significant meaning in model SDM Fe, showing that the complex vertical effect exists (Hoang and Goujon, 2014). It is a kind of agglomeration effect in which the provinces do not have competition but have positive connections. The foreigners tend to invest in the clusters in which there is a province with the highest foreign investment.

Figure 2 Provincial distribution of cumulative high technology FDI in Vietnam from 2007 to 2020 (millions of USD) (see online version for colours)



Source: Drawed by the author base on Geoda

This spatial dependence explains why cumulative high technology FDI is clustered in the country's North and South. Each cluster is centred around a core of provinces with the highest levels of FDI concentration (see map in Figure 2). The spatial dependence and the agglomeration effect are partly due to geographical characteristics such as national airports, seaports, and inland ports. Indeed, the provinces with the highest concentration levels are located near major ports, including Noi Bai Airport in Hanoi, Haiphong Port in Hai Phong, ICD Bac Ninh in the North; Da Nang Airport and Seaport in the Middle and Hochiminh Airport and Seaport in the South.

It shows that the provinces that receive the highest foreign investment are surrounded by Hanoi and Hochiminh, two centres of Vietnam. In the North, there is the appearance

of the cities such as Hanoi, Bac Ninh, Hai Phong, Vinh Phuc, and Ha Nam. Similarly, the cities that have appeared many times from 2007 to 2020 include Hochiminh, Ba Ria – Vung Tau, Binh Duong, and Dong Nai. The surrounding cities will positively affect human resources, transportation costs, and technology spillover. The new investors will continue to enter the provinces where incumbent firms exist in the same or related industry to receive the benefits listed in the agglomeration effect.

The agglomeration effect in our study emphasises three points: first, the high technology FDI clusters together to receive the positive spillover (shows in the dependent variables HTFDI are located into clusters); second, Table 5 shows that the GRDP and Ledu have positive meaning and have indirect impacts. It means that the HTFDI investors can access the potential labour in the contiguous provinces when they are located in a region. Third, the HTFDI can receive the advantage when located in or near the provinces with large markets to benefit from the suppliers or consumers.

5 Conclusions

In this paper, we have investigated the locational factors that affect high-technology FDI inflows into sub-national units in Vietnam, taking into account institutional determinants and traditional determinants with the spatial regression model. Using a dataset on registered high technology FDI capital in 63 Vietnamese provinces from 2007 to 2020 and drawing on recent developments in spatial regression methodology, we have discovered several empirical patterns that enhance the existing evidence base and may inform policy and practice.

Firstly, PCI is a good and reliable governance indicator for the State to attract the acquisition of one province and improve the neighbourhood locality.

Secondly, the government should improve the source of land and build modern infrastructure in industrial zones with a clear legal corridor to attract more foreign investors.

Thirdly, we do not recommend wage moderation as a province-level policy to attract HTFDI, although the wage variable has a negative significance to the FDI attraction. The provinces with the highest wage are also the provinces that have the highest FDI. The highest FDI provinces within such clusters would be better placed to afford wage moderation than provinces with low per-capita wages and HTFDI concentration levels. Therefore, wage moderation as a means of attracting FDI is likely to perpetuate inter-province disparity in FDI concentration and average wage level.

From the research, the high technology companies are distributed unevenly in 63 provinces. They primarily concentrated on the Red River Delta and the Southeast region, accounting for more than 75% of total capital. Moreover, this trend has stayed the same for a long time, and the distance between the provinces has been prolonged.

The study addressed a significant sector in Vietnam and gave vital insights into Vietnamese policymakers in the high-technology industry sector. However, some limitations must be considered in the following studies. First, the study only concentrated on the manufacturing and process industry, emphasising the firms producing high-technology products rather than the service industry or high-tech agriculture. The second is the classification of high-tech FDI based on the classification of OECD but not based on the Vietnamese High-Tech Law 2019 because of the restricted data. Thirdly, the

agglomeration effect is not covered in the institution variables. In Vietnam, the institution indexes at the province level are relatively restricted and unreliable. In a further study, the author will continue to apply the agglomeration effect to study the high technology variables as the critical determinants and use the high tech FDI classified by the Vietnamese law to evaluate the impact of the technology environment to attract high technology FDI in the province level in Vietnam.

Acknowledgements

The authors gratefully acknowledge the contribution of Associate Professor Vu Hoang Nam – Foreign Trade University for the valuable discussions and comments. Nevertheless, the research team accept full responsibility for the contents of this paper.

Funding

This study is a result of a research with the title "Application of Mathematics models in DataScience to solve some socio-economic problems in Vietnam".

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Appendix

Table A1 Summary of spatial – weighting object WC

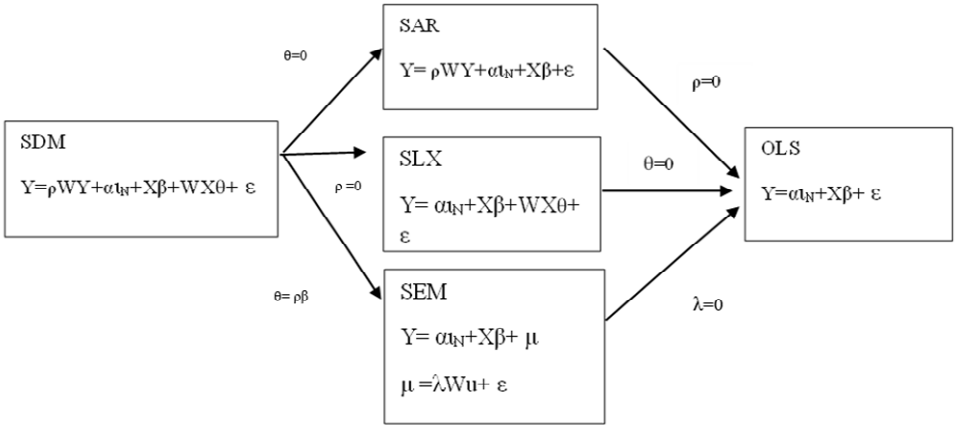
Matrix	*Description*
Dimensions	63 × 63
Stored as	63 × 63
Links	
Total	270
Min	2
Mean	4.285714
Max	8

Table A2 Estimation results of models with no spatial effect

	Pooled OLS	*Spatial FE*	*Time-period FE*	*Two-way FE*
PCI_lag1	0.0417 (0.46)	0.103** (0.06)	0.0775 (0.22)	0.0788 (0.20)
Aland	0.318 (0.36)	0.624** (0.04)	0.333 (0.38)	1.081*** (0.00)
Trans	–0.249 (0.53)	0.273 (0.42)	–0.144 (0.74)	0.221 (0.55)
LPI	0.176*** (0.00)	0.147*** (0.00)	0.614*** (0.00)	0.0861 (0.59)
Ledu	0.384*** (0.00)	0.202* (0.07)	0.529*** (0.00)	0.113 (0.40)
Rwage	0.00138** (0.01)	0.000819 (0.13)	0.00400*** (0.00)	0.000999 (0.21)
LeduRwage	–0.0000480** (0.04)	–0.0000181 (0.38)	–0.0000977*** (0.00)	–0.0000235 (0.32)
lnGRDP	3.481*** (0.00)	1.098 (0.18)	2.873*** (0.00)	0.271 (0.81)
_cons	–40.23*** (0.00)	–90.37*** (0.00)	–27.44** (0.02)	26.91 (0.47)
AIC	5,954.42	5,553.502	5,932.756	5,435.73
BIC	5,997.399	5,892.553	6,033.039	5,502.681

Source: Calculated by the author based on Stata

Figure A1 Comparison of different spatial econometric model specifications



Source: Elhorst (2017)

Table A3 The LR test result for pooled OLS, time-period FE and spatial FE

. lrtest PooledOLS TimePeriodFE, stats dir						
Likelihood-ratio test				LR chi2(12) = 45.80		
(Assumption: PooledOLS nested in TimePeriodFE)				Prob > chi2 = 0.0000		
Akaike's information criterion and Bayesian information criterion						
Model	*Obs*	*ll(null)*	*ll(model)*	*df*	*AIC*	*BIC*
PooledOLS	882	–3,159.009	–2,987.629	9	5,993.258	6,036.298
TimePeriodFE	882	–3,159.009	–2,964.728	21	5,971.456	6,071.882
name	*command*	*depvar*	*npar*	*title*		
PooledOLS	regress	lnHtfdi	9			
TimePeriodFE	regress	lnHtfdi	23			
. lrtest PooledOLS SpatialFE, stats dir						
Likelihood-ratio test				LR chi2(62) = 531.09		
(Assumption: PooledOLS nested in SpatialFE)				Prob > chi2 = 0.0000		
Akaike's information criterion and Bayesian information criterion						
Model	*Obs*	*ll(null)*	*ll(model)*	*df*	*AIC*	*BIC*
PooledOLS	882	–3,159.009	–2,987.629	9	5,993.258	6,036.298
SpatialFE	882	–3,159.009	–2,722.082	71	5,586.164	5925.7
Name	*command*	*depvar*	*npar*	*title*		
PooledOLS	regress	lnHtfdi	9			
SpatialFE	regress	lnHtfdi	72			

Note: N = Obs used in calculating BIC; see [R] BIC note.