REVEALING THE EFFECTS OF DIFFERENT KNOWLEDGE SPILLOVERS FROM FDI ON GREEN TOTAL FACTOR PRODUCTIVITY

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Abstract: ***Productivity growth is crucial for growing welfare gains. This study looked at the impact of FDI knowledge spillover on production. In addition to the traditional OLS, FE, and FGLS approaches, system generalized methods of moments (S-GMM) are used to investigate data from several official databases in 63 Vietnamese provinces from 2011 to 2022. The regression analysis shows that: (1) Higher levels of depth of human capital knowledge spillovers can significantly improve provincial green productivity; (2) Higher levels of depth of organizational knowledge spillover through FDI and breadth of human capital knowledge spillover from FDI can reduce green productivity of provinces; (3) The depth of human capital knowledge spillover from FDI can more significantly and effectively promote green total factor productivity Our findings offer insight on the indirect effects of foreign direct investment on green productivity at the regional level.***

• Keywords: *human capital knowledge spillovers, knowledge spillovers from FDI, organizational knowledge spillovers, green total factor productivity*

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1. Introduction

Because of the direct link between increased productivity and welfare benefits, there has been a growing interest in understanding the determinants of productivity variations within and among nations during the previous few decades. FDI activity has long been proposed as a potential explanation for these disparities (Bournakis & Tsionas, 2022).

Although numerous scholars have investigated the link between FDI spillovers and productivity, few have examined the relationship at the provincial level. Furthermore, past research has primarily employed microeconomic methodologies, firm or industry level analysis, and produced mixed results (Belitski et al., 2023; (Li et al., 2019), with a few studies using macro-level data, such as Malikane & Chitambara (2018).

For a variety of reasons, we selected the province as the unit of study. First, there is significant regional heterogeneity in institutional and economic elements that can influence productivity. Second, as shown in the current literature, spatial closeness is essential for technology and knowledge spillovers (Jaffe, 1989). Third, changes in regional FDI attractiveness policies influence not just FDI inflows but also the cost of doing business across regions (Chan et al., 2010). As a result, there is an urgent need to investigate the relationship between FDI knowledge spillovers and regional productivity in order to acquire a deeper understanding of the interaction of place, space, and organizations.

The aim of this research is to investigate the effects of FDI knowledge spillovers on productivity through the lens of organizational and human capital knowledge spillovers. In addition to the traditional OLS, FE, and FGLS approaches, system generalized moments (S-GMM) are used on a panel data set of 63 provinces in Vietnam from 2011 to 2022, with a total of 756 observations used. First, productivity, as measured by green total factor productivity (GTFP), is calculated using the global Malmquist-Luenberger index and data envelopment analysis (DEA). Second, the organizational and human capital knowledge spillovers from FDI and GTFP are incorporated into the same theoretical framework to investigate the link between the three variables. Finally, the heterogeneity effect is introduced into the model to better analyze the impact of knowledge spillover from FDI on productivity in various locations.

This work adds to literature in several ways. First and foremost, this is groundbreaking research of the impact of FDI knowledge spillovers on productivity, looking at both organizational and human capital knowledge spillovers. While most research categorizes knowledge spillovers based on their development mechanism and spillover channel (Havranek & Irsova, 2011), this study examines different channels of knowledge spillovers from FDI that may substitute for one another. Second, this study uses a regional approach to analyzing the influence of FDI knowledge spillovers on production since spatial proximity is important for technology and knowledge

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spillovers (Jaffe, 1989). Finally, this study illustrates the various effects of FDI-induced knowledge spillover on green productivity in different regions of Vietnam.

This study suggests that future provincial productivity policies should examine and balance the number of foreign and local firms to create a competitive environment in an area and reduce the potential crowding-out effects of knowledge spillovers. Professional conferences and trade fairs should also be promoted as forums for knowledge exchange between foreign and local employees.

The following is the rest of the article: Section 2 explains the theoretical underpinnings of this investigation, whereas Section 3 gives the data and empirical framework of this research. Section 4 summarizes the key findings, and Section 5 concludes.

2. Literature review and hypothesis development

Scholars hold varied viewpoints on knowledge spillovers. Ferreira et al. (2017), for example, proposed that knowledge spillover may be caused by knowledge externality and that businesses could profit from the technical breakthroughs and R&D of competitors. Pan and Liu (2013) define knowledge spillovers as the effect of a firm's R&D operations on innovative performance. Kim (2015) defined transnational knowledge spillover as a favorable external outcome of FDI-induced productivity growth in host nations. Knowledge spillovers from FDI are defined in this study as a positive externality that boosts indigenous firms' knowledge because of the presence of foreign operations in the region

Endogenous growth literature recognizes knowledge spillovers as an important factor in explaining domestic productivity, and FDI is viewed as a conduit for spillovers, through which technological innovations and knowledge about themselves can be transferred and transformed to meet local demands Ali et al. (2016).

Although various studies have been undertaken on the relationship between FDI and productivity, little scholarly attention has been dedicated to its regional distribution (Li et al., 2019). Previous study, which used microeconomic approaches, firm or industry level analysis, yielded varied outcomes (Girma, 2005; Meyer and Sinia, 2009). Given that scholarly research indicates that regions differ in both large and small countries due to significant developmental disparities (Bravo-Ureta et al., 2020), it is critical to investigate the mechanism of knowledge spillovers from FDI to local firms in order to understand the effect of FDI knowledge spillovers on provincial productivity.

In this work, we distinguish between two forms of knowledge spillovers from foreign direct investment. FDI knowledge spillovers can be further divided into organizational and human capital knowledge spillover. Even though these spillovers come from the same source, foreign-owned businesses, they may be substitutes for one another.

2.1. Organizational knowledge spillover from FDI and productivity

Spatially nearby foreign enterprises generate positive information externalities (Mariotti et al., 2010), which encourages more foreign firms to locate in the region. Increasing the quantity and density of foreign enterprises in a region creates more opportunities for knowledge and experience exchange in a given spatial setting (Argote & Miron-Spektor, 2011).

Prior literature outlined the mechanisms of such vicarious learning, which occurs when domestic companies watch and source knowledge from foreign firms via direct knowledge transfer of spillovers, changes in their routines, and behaviors.

Localized organizational spillovers from multinational companies are viewed as a source of new competencies and capabilities for existing domestic firms (Shepherd & Patzelt, 2022). Knowledge spillovers will also generate new ideas, best practices, and the spread of excellence throughout an organization, all of which relies on the collection, communication, relocation, and connection of information among organizational members (Shepherd & Patzelt, 2022). In this manner, knowledge spillovers promote industrial and technical growth in the region while simultaneously reducing environmental pollution, proving the province's GTFP. Spillovers that drive GTFP may result from the breadth (number of MNEs) and depth (concentration in a region) of organizational knowledge. First, the greater the number of foreign MNEs present, the more diverse the breadth of possible knowledge sources available to provide domestic firms with potential inputs, insights, and opportunities to develop organizational learning and capabilities to imitate and transform them into production technology and management methods with their own local characteristics (Fosfuri & Motta, 2001). Second, the density of foreign MNEs increases the possibility that a foreign firm may participate in an inter-firm interaction between foreign and domestic enterprises, hence raising the total depth or volume of unique foreign knowledge spillover. Employee turnover, demonstration, and market intermediaries can all contribute to knowledge spillover (Spencer, 2008)), which promotes new discoveries, best practices, and the spread of excellence (Shepherd & Patzelt, 2022).

To summarize, the breadth of knowledge spillover captures information novelty and diversity (Beliski et al., 2023). greater the variety of potential knowledge sources available, the more inputs, insights, and opportunities for local enterprises to expand their organizational learning and capacities. Meanwhile, organizational knowledge

spillover depth measures information volume (Beliski et al., 2023). At the same time, the greater the density of foreign firms, the more likely it is that a foreign enterprise will engage in inter-firm interaction with domestic firms, increasing the overall depth or amount of novel foreign knowledge spillover that can be combined with the organizational structures, practices, networks, and rules of FDI-owned firms to generate new products and services. As a result, we propose the first two hypotheses.

Hypothesis 1: Higher levels of organizational knowledge spillover breadth from FDI will affect green TFP improvement.

Hypothesis 2: Higher levels of organizational knowledge spillover depth from FDI will affect green TFP improvement.

2.2. Human capital knowledge spillover from FDI and productivity

The arrival of foreign enterprises in an area is accompanied by the hiring of a large number of workers with comprehensive and sophisticated working knowledge of the domestic market. These individuals can quit foreign corporations to start their own businesses, or they can join new firms as key members, leveraging industry knowledge gained in foreign firms, resulting in human capital knowledge spillover in an area. Individual knowledge and skills are enhanced by managerial abilities to combine knowledge flows and use knowledge embedded in humans (i.e., human capital) in other organizations.

Tacit knowledge is conveyed to other organizations through face-to-face interactions between foreign personnel and staff from other enterprises co-located in a region (Beliski et al., 2023). Human capital knowledge spillover to GTFP growth occurs through management communication between employees working at different enterprises in a region that may sprout. Managerial contacts between employees from diverse FDI businesses and domestic counterparts in an area, for example, can spark fresh ideas and lead to creative solutions that have a greater influence on efficiency and production (Helfat & Martin, 2015). As a result, we propose the following two hypotheses.

Hypothesis 3: Higher levels of human capital knowledge spillover breadth from FDI will affect green TFP improvement.

Hypothesis 4: Higher levels of human capital knowledge spillover depth from FDI will affect green TFP improvement.

3. Research design

3.1. Data and variable definitions

This study is based on a balanced Vietnam panel data set of 63 cities and provinces polled between 2011 and 2022. The data set was compiled from the Socio-Economic Statistical Data of 63 Provinces and Cities, the Vietnam Statistical Yearbook, the appropriate annual Vietnamese Provincial Statistical Yearbook, and the White Books on Vietnamese Businesses.

Table 1. Variable descriptions and measurements

Variable	Measurements	Unit
Dependent variable		
Green total factor productivity (GTFP)	Global Malmquist Luernberger index	%
Independent variables		
Breadth of organizational knowledge spillover (Breath_OR_FS)	Natural logarithm of number of foreign firms in a region	%
Depth of organizational knowledge spillover (Depth_OR_FS)	Share of foreign firms in a region	%
Breadth of human capital knowledge spillover (Breath_HC_FS)	Natural logarithm of the number of employees in foreign firms in a region	%
Depth of human capital knowledge spillover (Depth_HC_FS)	Share of employment in foreign firms in a regional	%
Control variables		
Marketization (MAR)	Ratio of employees of non-state-owned businesses to all employees in a province	%
Energy structure (ES)		%
Industrial structure (IS)	Percentage of coal consumption that is converted to standard coal relative to the total energy consumption in a province	%
Trade openness (OPEN)	Proportion of GDP to total goods imported and exported serves as a proxy for trade openness	%

The descriptive statistics for the variables are shown in Table 2.

Table 2. The variables' descriptive statistics

	Obs	Mean	Std. Dev.	Min	Max
GTFP	756	1.0012	0.0131	0.9064	1.0771
Breath_OR_FS	755	3.4889	1.9282	0.0000	8.92319
Depth_OR_FS	755	1.9042	2.5236	0.0000	16.6933
Breath_HC_FS	756	9.0243	2.6768	0.0000	13.4957
Depth_HC_FS	756	33.6959	35.9434	0.0000	100
MAR	756	92.1182	31.6316	46.4170	930.9856
IS	756	1.11E-05	0.0001	6.92E-08	0.0034
ES	756	21.2563	6.2206	6.1265	48.8396
OPEN	756	173.6842	549.4547	5.11E-07	9627.54

Table 2 displays the model variable's descriptive statistics. The final sample consists of 756 observations from Vietnam's 63 provinces collected between 2011 and 2022. The mean GTFP score of 1.002 indicates significant variability in green productivity between provinces and years, with values ranging from 0.906 to 1.077. With standard deviations ranging from 1.9282 to 35.9434 and average levels of FDI spillover ranging from 1.9042 to 33.6959, there appear to be significant geographical disparities in how knowledge from FDI has diffused.

3.2. Model settings

To investigate the impact of various types of FDI knowledge spillover on green total factor production, as described in Hypotheses 1-4, the following panel model is developed:

$$GTFP_{it} = \alpha_0 + \alpha_1 GTFP_{it-1} + \alpha_2 FS_{it} + \sum_{i=3}^{k} \alpha_i X_{it} + \mu_i + \mu_t + \epsilon_{it} \quad (1)$$

Where i and t denote the city and year, respectively. $GTFP_{it}$ is the proxy of green total factor productivity. The

primary explanatory variable that denotes knowledge spillover from FDI is $FDIspill_{it}$. The coefficient of interest is α_1, which reveals the influence of FDI knowledge spillover on TFP. X_{it} denotes a collection of control variables including markelization (MAR), industrial structure (IS), energy consumption structure (ES), and trade openess (OPEN). μi and μt are fixed effect in region and time, respectively.

4. Results and discussions

4.1. Main results

In this part, econometric approaches are used to empirically validate the theoretical hypothesis given earlier. As the lag term for the dependent variable is introduced, the independent variable may become linked with a random error term. As a result, endogeneity-induced deviation is eliminated using the FGLS and system-GMM models.

Table 3 highlights the empirical findings on the influence of various types of knowledge spillover from FDI on GTFP. The Arellano-Bond (AR) test results reveal that the random error terms' first order difference items are autocorrected at the 1% significance level, while the second-order difference items are not. The Hansen test results show that the null hypothesis cannot be rejected at a 10% significance level. As a result, the system-GMM model passes both the AR and Hansen tests, indicating that the model is plausible and the results credible.

First, as shown in Table 3, the FLGS and system-GMM models have a negative and significant coefficient on the lagged term of GTFP, indicating that GTFP growth is continuous and dynamic.

Second, the estimated coefficients of knowledge spillover from FDI are mostly significant, except for organizational knowledge spillover. The coefficient representing the breadth of organizational knowledge spillover (Breath_OR_FS) is not significant. This implies that increasing the number of foreign enterprises in a province has little effect on the local GTFP. As a result, hypothesis 1 becomes invalid. The loose business connectivity between FDI-invested enterprises and their domestic counterparts may contribute to the issue's potential growth. Vietnamese enterprises rarely participate in foreign firms' supply chains, resulting in limited knowledge transfer.

The remaining FDI spillover forms have clearly different directions. According to system GMM estimates, the coefficients of depth of organizational knowledge and breadth of human capital knowledge spillover are strongly negative. Specifically, increasing the share of foreign enterprises in a province (organizational spillover depth) reduces provincial green productivity growth because the depth of knowledge spillover coefficient (depth_OR_FS) is notably negative, leading to hypothesis 2 is validated. Similarly, the calculated coefficient of breadth of human capital knowledge spillovers (breath_HC_FS) is strongly negative, implying that an increase in the number of employees in foreign enterprises hinders a province's GTFP growth. Therefore, theoretical hypothesis 3 is confirmed. One possible cause is that an enormous amount of foreign enterprises and personnel came from minuscule foreign firms with limited technology, therefore knowledge spillover from overseas firms is not new or updated. As a result, this will be detrimental to GTFP growth.

Table 3

Dependent variable: GTFP	POLS	FE	FGLS	SGMM
	(1)	(2)	(3)	(4)
L.GTFP			-0.634***	-0.206***
			(0.0357)	(0.0643)
Breath_OR_FS	0.0033	0.0032	0.0027	-0.0007
	(0.0041)	(0.0043)	(0.0028)	(0.0052)
Depth_OR_FS	-0.0105***	-0.0108***	-0.0060***	-0.0064**
	(0.0030)	(0.0032)	(0.0022)	(0.0032)
Breath_HC_FS	-0.0092**	-0.0101**	-0.0060***	-0.0053*
	(0.0037)	(0.0040)	(0.0022)	(0.0031)
Depth_HC_FS	0.0102***	0.0107***	0.0027	0.0067***
	(0.0032)	(0.0034)	(0.0028)	(0.0025)
MAR	-0.0091	-0.0093	-0.0064	-0.0064*
	(0.0057)	(0.0059)	(0.0091)	(0.0033)
IS	0.0013*	0.0012	0.0014**	0.0021*
	(0.0007)	(0.0008)	(0.0006)	(0.0012)
ES	0.0273***	0.0274***	0.0160***	0.0231***
	(0.0039)	(0.0041)	(0.0027)	(0.0052)
OPEN	0.0002	0.0002	0.0018***	0.0030***
	(0.0002)	(0.0002)	(0.0005)	(0.0011)
Constant	-0.0009	-0.0009	7.31e-05	-0.0003
	(0.0009)	(0.0009)	(0.0008)	(0.0005)
R-squared	0.106	0.107		
AR(1)				0.0000
AR(2)				0.674
Hansen test				0.102

*Note: (1) The values in parentheses are robust standard errors clustered at the provincial level; (2) ***, ** and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.*

In contrast, the fraction of such employees (Depth_HC_FS) is crucial for raising GTFP (β=0.067, p<0.001). As a result, hypothesis 4, which claims that increased levels of human capital knowledge spillover via FDI raise GTFP, is supported. Interactions between international and domestic personnel make knowledge adaptable to local contexts, which strengthens the GTFP in the local provinces.

Finally, regression results for effects of control variables on GTFP demonstrate that the coefficients of industrial structure (IS), energy structure (ES), and trade openness (OPEN) were all significantly positive. This means that trade liberalization and industrial structure optimization play major roles in improving GTFP. Meanwhile, Vietnam's economic growth remains strongly dependent on natural resources such as coal, therefore increased coal consumption continues to contribute to GTFP. However, improved marketization (MAR) has a negative influence on GTFP. One possible

factor is an insufficient connectivity between private enterprises and other sectors of the Vietnamese economy.

4.2. Heterogeneity of provincial location

To provide a theoretical foundation for developing varied investment policies, the study sample is further separated into three regions: northern, central, and southern provinces. Its aim is to investigate the influence of various FDI-induced knowledge spillovers on green productivity in different regions of Vietnam.

Table 4. Estimation results of province location

Dependent variable: GTFP	North	Central	South
	(1)	(2)	(3)
Breath_OR_FS	-0.0063	-0.0042	0.0127
	(0.0079)	(0.0059)	(0.0111)
Depth_OR_FS	-0.0040	-0.0032	-0.0158**
	(0.0086)	(0.0039)	(0.0060)
Breath_HC_FS	0.0085*	-0.0005	-0.0188**
	(0.0049)	(0.0038)	(0.0072)
Depth_HC_FS	-0.0049	0.0049*	0.0099***
	(0.0042)	(0.0028)	(0.0033)
Control variables	Yes	Yes	Yes
AR(1)	0.0000	0.0000	0.0000
AR(2)	0.665	0.599	0.661
Hansen test	0.161	0.215	0.142

*Note: (1) The values in parentheses are robust standard errors clustered at the provincial level; (2) ***, ** and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.*

Table 4 shows that the provinces in the southern region have a higher estimated coefficient of depth human capital knowledge spillover from FDI than those in the northern and central regions. The southern region has a stronger economic foundation and resource endowment, as well as a larger talent pool, so the depth of human capital knowledge spillover from FDI can improve green total factor productivity more significantly and effectively than the two remaining regions.

5. Conclusions

Prior research has shown an increasing interest in studying the impact of FDI spillovers on productivity (Bournakis and Mallide, 2021; Malikane and Chitambara, 2017). FDI has been associated with both positive and negative spillovers (Girma, 2005; Meyer and Sinia, 2009). However, the impact of knowledge spillovers from FDI on a province's production has remained unknown. In this regard, our analysis underlines the importance of FDI knowledge spillovers in aiding a province's productivity growth by introducing new insights, best practices, and creative opportunities.

This study analyzes the breadth and depth of organizational and human capital knowledge spillovers and their impact on provincial green productivity. The research conclusions are as follows, based on panel data from 63 Vietnamese cities and provinces from 2011 to 2022: (1) Higher levels of depth of human capital knowledge spillovers can significantly improve provincial green productivity; (2) higher levels of depth of organizational knowledge spillover through FDI and breath of human capital knowledge spillover from FDI can reduce green productivity of provinces; (3) The depth of human capital knowledge spillover from FDI can more significantly and effectively promote green total factor productivity in provinces in the south than that of the central and north of Vietnam.

The following policy recommendations are made in light of the findings. First, while welcoming foreign firms to a region, local governments should consider the potential unintended consequences. A policy that promotes foreign investment without taking into account the country's current resources and competencies would diminish provincial green productivity. To create a competitive environment in a region, it is critical to analyze and balance the number of foreign and domestic firms. Second, governments should promote the hiring of foreign experts and skilled workers in a region, as well as an increase in their proportion of the territory's workforce. Furthermore, the regional engagement of FDI workers is intrinsically connected to increased local green TFP. As a result, more professional conferences and trade fairs are required to improve knowledge exchange among foreign and local employees. Third, significant human capital is required for the knowledge spillovers from FDI to be beneficial. As a result, it is vital for a province to create highly skilled individuals.

One limitation of our analysis is that we are unable to account for various important parameters such as FDI business size and technological capacity. The issue could be resolved in the future by merging data from enterprise surveys. We anticipate that including company heterogeneity controls will make related research more rigorous.

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