Urata, Shujiro; Baek, Youngmin

Working Paper

Technology spillover and absorptive capacity of firms and countries

ADBI Working Paper, No. 1323

Provided in Cooperation with:
Asian Development Bank Institute (ADBI), Tokyo

Suggested Citation: Urata, Shujiro; Baek, Youngmin (2022) : Technology spillover and absorptive capacity of firms and countries, ADBI Working Paper, No. 1323, Asian Development Bank Institute (ADBI), Tokyo

This Version is available at:
https://hdl.handle.net/10419/267756

ADBI Working Paper Series

TECHNOLOGY SPILLOVER AND ABSORPTIVE CAPACITY OF FIRMS AND COUNTRIES

Shujiro Urata and Youngmin Baek

No. 1323
June 2022

Asian Development Bank Institute

Shujiro Urata is a visiting fellow at the Asian Development Bank Institute and professor emeritus of Waseda University, Japan. Youngmin Baek is an assistant professor at Fukuyama University, Japan.

Suggested citation:

Urata, S. and Y. Baek. 2022. Technology Spillover and Absorptive Capacity of Firms and Countries. ADBI Working Paper 1323. Tokyo: Asian Development Bank Institute. Available: https://www.adb.org/publications/technology-spillover-and-absorptive-capacity-of-firms-and-countries

Please contact the authors for information about this paper.

Email: surata@adbi.org

The authors thank Shandre Thangavelu and other participants at ADBI Workshop for their helpful comments and discussions.

Asian Development Bank Institute
Kasumigaseki Building, 8th Floor
3-2-5 Kasumigaseki, Chiyoda-ku
Tokyo 100-6008, Japan

Tel: +81-3-3593-5500
Fax: +81-3-3593-5571
URL: www.adbi.org
E-mail: info@adbi.org

Abstract

The paper examines the foreign direct investment (FDI) spillover effects in developing countries and investigates the importance of the absorptive capacity of a firm and a country in realizing and facilitating FDI spillover. It uses data obtained from the World Bank's Enterprise Surveys for 107 countries from 2007 to 2020. The study finds that firms in developing countries do not benefit from horizontal FDI but benefit from forward and backward vertical FDI. The study also finds that firms can benefit from horizontal, forward, and backward FDI by improving the absorptive capacity of firms and host countries. Based on these findings, several recommendations are presented to help firms benefit from FDI spillover.

Keywords: foreign direct investment, technology transfer, absorptive capacity

JEL Classification: D22, F21, O3, R1

Contents

1. INTRODUCTION

Technology plays an important role in determining the competitiveness of a firm, as possession of advanced and efficient technology enables a firm to reduce production costs and increase productivity. Furthermore, possession of technology enables a firm to develop new products, improving its competitiveness. Previous discussion of the importance of technology for a firm's competitiveness can be applied to a country, where technological progress is key to achieving economic growth. Even with the same magnitude of factors of production—that is, labor and capital—technological progress leads to an expansion in production, or economic growth.

A firm may obtain technology internally as well as externally. A firm may obtain technology internally by developing new technology through research and development. A firm may also obtain technology externally through various channels, including purchasing licenses or patents, attending external seminars, hiring engineers, importing capital goods, doing business with foreign firms, and others. Firms obtain technology directly by purchasing licenses and patents, attending seminars, and hiring engineers, while technology is obtained indirectly by importing capital goods and doing business with foreign firms. Firms acquire technology through reverse engineering in the case of importing capital goods, and through their contact with foreign firms. Both types of technology acquisition are described as technology spillover. In this paper, we examine the latter type—that is, technology spillover through contact with foreign firms. In particular, we focus on technology spillover to domestic firms from foreign firms operating in developing countries, set up by foreign direct investment (FDI). As such, we use the expression "FDI spillover" in our study to describe technology spillover through foreign firms. In recent years, the attention of policymakers, business persons, and researchers to FDI spillover has increased, as the importance of FDI in transferring technology internationally is increasing with rapid expansion of FDI.

Technology spillover from foreign firms to domestic firms, or FDI spillover, is realized in various forms, including labor mobility, imitation, business transactions, etc.[1] Workers who have acquired technology by working for foreign firms may transfer technology to domestic firms when they are hired by them. Domestic firms may obtain technology by observing foreign firms' behavior, such as production methods and other business practices. These two types of spillover tend to take place where domestic and foreign firms operate in the same industry and are thus characterized as horizontal spillover (linkage). Domestic firms may acquire technology through their business relations with foreign firms. We can classify business relationships into two types, backward and forward linkages. FDI spillover through backward (forward) linkage is described as backward (forward) spillover. Backward spillover takes place when domestic firms supply parts and semi-finished products to foreign firms, while forward spillover occurs where foreign firms supply parts and semi-finished products to domestic firms. Within customer-supplier business relationships, domestic firms acquire technology through channels such as the certification process and training courses.

The objective of this paper is to analyze empirically the presence or absence of FDI spillover, and horizontal and vertical (backward and forward) spillovers. There have been many studies on this subject, but no consensus has been reached. We hope to make new contributions to the literature. While many empirical studies have examined the issues for a particular country, our study considers 107 countries. Our study can therefore identify the characteristics of countries that have an impact on FDI spillover,

[1] On the typology of technology spillover, see, for example, Lesher and Miroudot (2008).

enabling us to provide useful information for policymakers responsible for trade, industry, or technology policies.

The structure of our papers is as follows. Section 2 provides a brief literature review and summarizes the main findings of previous studies, as well as identifying unsolved issues. Section 3 presents the methodology and data used for the analysis, while section 4 presents and discusses the estimation results. Section 5 concludes the paper.

2. LITERATURE REVIEW

In this section, studies on technology spillover and the absorptive capacity of FDI spillover are reviewed to set the stage for our analysis. We first review studies on the FDI spillover effect and then turn to those focusing on the absorptive capacity in FDI spillover.

There are a large number of empirical studies that have examined the presence or absence of technology spillover via FDI, FDI spillover. Their results are mixed. Table 1 shows the results of recent empirical studies using firm-level data since the early 2000s. In many studies, the effect of horizontal FDI spillover on a firm's productivity was not statistically significant (Javorcik 2004; Blalock and Gertler 2009; Wang 2010; Farole and Winkler 2012; Gorodnichenko et al. 2014; Newman et al. 2015; Dogan et al. 2017). Only a few studies found statistically significant results. The estimated coefficient of horizontal FDI was found to be positive and statistically significant for developed countries such as the UK (Haskel et al. 2007) and the US (Keller and Yeaple 2009), while negative and statistically significant results were obtained for developing countries such as the People's Republic of China (Lu et al. 2017). These results suggest that positive FDI spillover occurs but not everywhere (Keller 2004). In developing countries, the presence of competitive foreign firms takes market away from domestic firms, reducing domestic firms' sales and production, while the presence of foreign firms tends to benefit domestic firms via technology spillover in developed countries. Rojec and Knell (2018) claimed that there are substantive and methodological reasons for the mixed results of empirical studies. The substantive reason is that the necessary preconditions for FDI spillovers are often missing in host countries. Concerning the methodological reason, the authors argue that the quality of the databases used by many studies is insufficient and many studies apply inappropriate econometric methods.

Turning to the results on vertical FDI spillover, the results on forward FDI spillover are mixed. Positive results are found in Wang (2010) and Lu et al. (2017), while negative results are found in Javorcik (2004), Newman et al. (2015) and Dogan et al. (2017). In contrast, the results for backward FDI spillover are generally positive (Javorcik 2004; Wang 2010; Gorodnichenko et al. 2014; Newman et al. 2015; Lu et al. 2017) and statistically significant, except for Dogan et al. (2017). Summarizing the previous results, we can conclude that backward FDI spillover seems to take place, but no conclusive evidence has been found for horizontal and forward FDI spillovers.

Table 1: Selected Previous Studies

Author	Javorcik (2004)	Haskel et al. (2007)	Blalock and Gertler (2009)	Keller and Yeaple (2009)	Wang (2010)
Countries, Year	Lithuania Manufacturing Firms 1996–2000	UK Manufacturing Firms 1973–1992	Indonesia Manufacturing Firms 1988–1996	US Manufacturing Firms 1987–1996	Canada Manufacturing Firms 1973–1997
Estimation Method	Olley-Pakes 2 Stage Correction	DID	Fixed Effects	IV 2SLS	IV 2SLS First-Differencing
Dep.Var	Value-Added	ΔY, TFP	TFP	ΔTFP	TFP
Horizontal FDI	–	+**	+	+***	+
Forward FDI	–*				+***
Backward FDI	+**				+***

Author	Farole and Winkler (2012)	Gorodnichenko et al. (2014)	Newman et al. (2015)	Dogan et al. (2017)	Lu et al. (2017)
Countries, Year	78 Low and Middle-Income, Countries Manufacturing Firms 2006–2010	17 Transition Market Economies 2002 and 2005	Viet Nam Manufacturing firms 2009–2012	Malaysia Manufacturing firms 2000–2004	PRC Manufacturing firms 1998–2007
Estimaton Method	IV 2SLS	First-Differencing	First-Differencing	First-Differencing	IV 2SLS
Dep.Var	Labor Productivity	Δsales	TFP	ΔTFP	TFP
Horizontal FDI	–	+	+	–	–***
Forward FDI		+	–***	–***	+***
Backward FDI		+*	+**	–*	+***

Note: + and – indicate the signs of estimated coefficients; *, **, and *** indicate the statistical level of significance at 10%, 5%, and 1%, respectively.

Source: Authors' compilation.

Next, we review studies that examined the effect of absorptive capacity on FDI spillover. First, we review studies on domestic firms' absorptive capacity, and then the absorptive capacity of the host country. The most important factor for domestic firms to benefit from FDI spillover is the firm's technological capacity, which is reflected in high productivity. Glass and Saggi (1998) found that absorptive capacity for spillover is most affected by a firm's level of technological development. Nicolini and Resmini (2006); Keller and Yeaple (2009); Farole and Winkler (2012); and Damijan et al. (2013) show that firms need relatively high productivity to benefit from FDI spillover. Human capital capacity is another important absorptive capacity on the part of domestic firms for benefiting from FDI spillover. Girma et al. (2005), Gorodnichenko et al. (2006), and Damijan et al. (2013) highlighted the importance of human capital in terms of absorption capacity for FDI spillover. Damijan et al. (2013) found that firms with highly educated employees benefit from FDI spillover. Some studies found that firms with export experience, which tends to reflect high productivity, benefited more from FDI spillover than those without export experience (Damijan and Knell, 2005; Girma et al. 2005; Castellani and Zanfei 2007; Farole and Winkler 2012). These findings support the importance of high technological capability and high productivity to benefit from FDI spillover.

From the late 1990s to the 2000s, a number of studies were conducted on the impact of FDI on economic growth using macro-level data. These studies examined the effects of the host country's economic environment on FDI spillover using the interaction term of the host country's absorptive capacity and FDI inflow. Some studies found the presence of prerequisites for the host country to benefit from FDI spillover. Important prerequisites include an adequate level of human capital, economic and political stability, liberalized markets, and a well-functioning infrastructure (Bengoa and Sanchez-Robles 2003). Borensztein et al. (1998) found that human capital is important to benefit from FDI spillover. FDI is a vehicle for obtaining new technologies, and training the labor force to work with new technologies is important. Alguacil et al. (2011) investigated the effects of the institutional environment on FDI spillover, using economic freedom as a proxy for institutions. They found that a stable institutional environment increases FDI spillover. A good institution based on fair and stable legal and political systems reduces uncertainly and insecurity, enabling firms to assimilate technology from FDI (Alguacil et al. 2011). Alfaro et al. (2004) and Durham (2004) examined the role of the financial market, finding that the need for external finance increases when domestic firms reorganize their structure, purchase new machines, and hire new managers and skilled labor to take advantage of new knowledge.

Only a few studies that examined FDI spillover using firm-level data considered the host country's absorptive capacity, because most of these studies examined just one country. One of few exceptions is Farole and Winkler (2012), which investigated the impact of national absorptive capacity on horizontal FDI spillover for 78 low and middle-income countries from 2006 to 2010. Most of the effects of the host country's absorptive capacity on FDI spillover were not statistically significant.[2] We extend the work of Farole and Winkler (2012) by increasing the number of sample countries[3] and analyzing forward and backward spillovers, which they did not examine.

3. METHODOLOGY AND DATA

In this section, we explain the methodology used to estimate the FDI spillover effects and how the absorptive capacity mediates those effects. As for absorptive capacity, we examine the effect of the heterogeneity of domestic firms and host countries on FDI spillovers and further analyze the effect on FDI spillovers of the geographical distance between domestic and foreign firms. The baseline specification to examine FDI spillover effects is as follows.

$$lnLP_{isct} = \alpha + \beta FDI_{sct} + \gamma Z_{isct} + \delta_s + \delta_c + \delta_t + \varepsilon_{isct} \quad (1)$$

where $lnLP_{isct}$ is labor productivity of firm *i* in sector *s* of country *c* in year *t*. FDI_{sct} denotes horizontal, forward, or backward FDI interchangeably, as explained below, in sector *s* of country *c* in year *t*. Z_{isct} is a firm's characteristics that affect the firm's productivity, such as firm size, running of training programs, possession of quality

[2] Among labor freedom, financial freedom, investment freedom, business freedom, education, expenditure on R&D, trade openness, sector concentration, and GDP per capita, only education was positive and statistically significant. Meanwhile, sector concentration and trade openness had a positive effect on horizontal FDI spillover in the model of firms with low productivity.

[3] A list of sample countries is presented in Appendix Table 1.

certification, or adoption of foreign technologies.[4] δ_s, δ_c, and δ_t present sector, country, and year fixed effects, respectively.

To define three sector-level FDI linkages in country *c*, we refer to Javorcik (2004) as follows. Firstly, horizontal FDI captures the extent of the foreign presence in sector *s* at time *t* and is defined as the sales share of foreign firms in total sales in sector *s*. Horizontal FDI is used to examine the intra-industry spillover effects.

$$Horizontal_{st} = \frac{Sales_{st}^{F}}{Sales_{st}} \quad (2)$$

Secondly, forward FDI is defined as the weighted share of foreign firms' presence in upstream sectors of sector *s*. α_{sk} is the ratio of intermediate goods purchased from sector *k* to the total intermediate goods purchased by sector *s*. In other words, forward FDI spillover considers the effect when domestic firms purchase intermediate goods from foreign firms.

$$Forward_{st} = \sum_{k \neq s} \alpha_{sk} Horizontal_{kt} \quad (3)$$

Finally, backward FDI is defined as the weighted share of foreign firms' presence in downstream sectors of sector *s*. β_{sm} is the ratio of intermediate goods supplied by sector *s* to the total intermediate goods purchased by sector *m*. In other words, backward FDI spillover concerns the effect when domestic firms supply intermediate goods to foreign firms.

$$Backward_{st} = \sum_{m \neq s} \beta_{sm} Horizontal_{mt} \quad (4)$$

Both α_{sk} and β_{sm} are taken from Eora national input-output tables. In addition, since forward and backward FDI are vertical FDI,[5] intermediate goods purchased within the same sector are excluded from both forward and backward FDI.

We follow Blalock and Gertler (2009), as shown in equations 5 and 6, to examine the effect of the absorptive capability (AC) of domestic firms and host countries on FDI spillovers by introducing an interaction term of FDI with $AC_{isct\ or\ ct}$:

$$lnLP_{isct} = \alpha + \beta_1 FDI_{sct} + \beta_2 FDI_{sct} * AC_{isct} + \delta_s + \delta_c + \delta_t + \varepsilon_i \quad (5)$$

where AC_{isct} is firm *i*'s absorptive capacity in sector *s* of country *c* in year *t*, and is obtained from the responses to the World Bank's Enterprise Surveys questionnaire as follows.

- plargefirm (part of a larger firm) = Is the establishment part of a larger firm? (a binary variable that takes unity if the answer is "Yes", zero otherwise)
- qualitycert (internationally recognized quality certification) = Does this establishment have an internationally recognized quality certification? (a binary variable that takes unity if the answer is "Yes", zero otherwise)

[4] Size is the total number of permanent employees in natural logarithms. For training programs, quality certification, and adaptation of foreign technologies, see AC_{isct} in equation 5.

[5] Note that forward and backward FDI here are defined based on the sector with foreign firms' presence.

- foreigntech (foreign technology) = Does this establishment at present use technology licensed from a foreign-owned company, excluding office software? (a binary variable that takes unity if the answer is "Yes", zero otherwise)
- training (training programs) = Does this establishment have formal training programs for its permanent, full-time employees? (a binary variable that takes unity if the answer is "Yes", zero otherwise)
- gvc (firm's GVC participation) = GVC (global value chain) firm is defined as a firm which imports intermediate goods and exports output (a binary variable that takes unity if firm *i* is a GVC firm, zero otherwise)

It is expected that "plargefirm" will facilitate FDI spillover as a firm belonging to a large firm is likely to obtain assistance such as technical and financial assistance, which may be used to absorb technology; and that "qualitycert ," "foreigntech ," and "training " will contribute to facilitating a firm to benefit from FDI spillover. Both "qualitycert" and "foreigntech" indicate a firm's high technical capability, although they reflect different capabilities: "qualitycert" shows a firm's capability in developing technology, while "foreigntech" shows a firm's capability in using or adopting technology. Meanwhile, "training" indicates a firm's positive attitude toward absorbing technology, while "gvc" is likely to promote technology acquisition, as GVC provides opportunities to acquire technology through exporting and importing.

$$lnLP_{isct} = \alpha + \beta_1 FDI_{sct} + \beta_2 FDI_{sct} * AC_{ct} + \delta_s + \delta_r + \delta_t + \varepsilon_i \quad (6)$$

In equation 6, the effects of the characteristics of the host country or region[6] on FDI spillover are investigated through the interaction term of FDI_{sct} with AC_{ct}. AC_{ct} represents characteristics of the host countries included for the following variables.

- agglom (agglomeration) = The proportion of the total number of manufacturing firms in a domestic region in relation to the total number of manufacturing firms in a country. This measure is a proxy for locational advantages by agglomeration. This variable includes both domestic and foreign firms. (Data source: World Bank, Enterprise Surveys)
- tradeopen (trade openness) = Trade openness is the sum of exports and imports of goods and services measured as a share of gross domestic product. (Data source: World Bank, World Development Indicators)
- businessreg (business regulations) = This consists of six components (administrative requirements, bureaucracy costs, starting a business, extra payments/bribes/favoritism, licensing restrictions, and cost of tax compliance) obtained from the World Bank's Doing Business and the World Economic Forum's Global Competitiveness Report. This measure captures the overall business regulations. Countries with no business regulations earn a perfect 10, while ratings of countries with higher business regulations decline toward zero. (Data source: Fraser Institute's Economic Freedom Index using World Bank's Doing Business and World Economic Forum's Global Competitive Report)

[6] Only the variable of "agglom" is regional characteristics: the rest of the variables are country-specific characteristics.

- finanopen (financial openness) = Countries with the highest financial openness earn a perfect 10. In contrast, the ratings of the countries with lower financial openness decline toward zero. This measure is based on the Global Competitiveness Report of the World Economic Forum and indicates financial openness. (Data source: Fraser Institute's Economic Freedom Index using World Economic Forum's Global Competitive Report)
- education (school enrollment, tertiary) = Tertiary education is measured by the gross enrollment ratio for tertiary school and is a proxy for the quality of human capital. (Data source: World Development Indicators)
- ipr (International Property Rights Index) = The IPRI measures physical property rights, intellectual property rights, and the legal and political environments[7] (Data source: Property Rights Alliance's International Property Rights Index)

It is expected that "agglom" will promote FDI spillover, as it provides a firm with opportunities to acquire technology from other firms located in geographical proximity; "tradeopen" is expected to promote FDI spillover, as an open trade environment puts pressure on a firm to improve competitiveness by assimilating technology. Meanwhile, "businessreg" has a similar impact on FDI spillover to "tradeopen", as it ensures competition in the market. It is expected that "finanopen" will promote FDI spillover, as the availability of financial resources enables firms to purchase new machines and to hire engineers, which would facilitate technology spillover. It is likely that "education" will contribute to FDI spillover, because the availability of high-quality human resources facilitates a firm's technology acquisition; while "ipr" is expected to promote FDI spillover as it provides an environment where foreign firms may use technology actively without worrying about the misuse of their technology by other firms.

In estimating the FDI spillover effect, what is important is to address the endogeneity issue caused by reverse causality. Foreign firms tend to move to more productive, faster-growing, and profitable economies (Rodrik 1999), and high-productivity sectors or firms may attract foreign firms to the same location, yielding a positive relationship between them even without spillovers taking place (Rojec and Knell 2018). Therefore, to address the bias from reverse causality, equations 1, 5, and 6 are estimated using the instrumental variable (IV) method. We aggregate firms' responses to a question on senior management's time spent on dealing with regulations in the World Bank's Enterprise Survey at the sectoral level and use them as an instrument for our IV estimation. This industry-level instrument does not directly affect the firm's productivity but has a high correlation with the three types of FDI variable.[8]

We use a cross-sectional dataset of 18 manufacturing sectors[9] in 107 countries from 2007 to 2020 to estimate horizontal FDI spillover effects. For the estimation of forward and backward spillover effects, we use a cross-sectional dataset of seven sectors in 89 countries from 2007 to 2015, adopting the sector classification of Eora national input-output tables,[10] since it is necessary to connect Enterprise Surveys with Eora national input-output tables. All domestic currency units obtained from the World

[7] The following elements are considered for the three components: legal and political environment (judicial independence, rule of law, political stability, control of corruption),; physical property rights (protection of physical property rights, registering property, ease of access to loans); and intellectual property rights (protection of intellectual property rights, patent protection, copyright piracy).

[8] All interaction terms of absorptive capacity are also instrumented by their interaction terms with the aggregated time spent on regulations at the sectoral level.

[9] For the list of sample sectors, see Appendix Table 2.

[10] For the basic statistics, see Appendix Tables 3 and 4.

Bank's Enterprise Surveys are converted to USD using the official exchange rate and then deflated to the 2015 baseline year by GDP deflator for the US.

4. ESTIMATION RESULTS

We estimated equations 1, 5, and 6 by the ordinary least squares (OLS) and IV methods using data covering 18 sectors[11] and 107 developing countries from 2007 to 2020.[12] Table 2 shows the baseline results using OLS.[13] Columns 1, 3, and 5 are intended to investigate the factors determining labor productivity by including foreign firms as sample firms. The estimated coefficients of foreign firms are all positive and statistically significant, indicating that foreign firms' productivity is higher than that of domestic firms. This finding provides a rationale for us to investigate FDI spillover. The results of estimation using only the data on domestic firms are shown in columns 2, 4, and 6. The estimated coefficient on horizontal FDI is negative and statistically significant, while the coefficients of forward and backward FDI are statistically insignificant. Other variables have a positive effect on labor productivity, as expected.

Table 2: Baseline Results by OLS, World

	(1)	(2)	(3)	(4)	(5)	(6)
	Horizontal FDI		Forward FDI		Backward FDI	
FDI	–0.156	–0.314***	–0.121	–0.131	0.0387	0.0838
	(0.0970)	(0.0977)	(0.196)	(0.195)	(0.190)	(0.205)
lnsize	0.0542***	0.0650***	0.0587***	0.0755***	0.0587***	0.0753***
	(0.0116)	(0.0117)	(0.0170)	(0.0174)	(0.0170)	(0.0174)
training	0.213***	0.208***	0.230***	0.220***	0.230***	0.220***
	(0.0191)	(0.0197)	(0.0263)	(0.0271)	(0.0262)	(0.0271)
qualitycert	0.340***	0.299***	0.382***	0.334***	0.382***	0.334***
	(0.0230)	(0.0226)	(0.0299)	(0.0305)	(0.0298)	(0.0305)
foreigntech	0.199***	0.186***	0.243***	0.234***	0.242***	0.233***
	(0.0286)	(0.0280)	(0.0388)	(0.0366)	(0.0392)	(0.0371)
foreign firm	0.320***		0.303***		0.304***	
	(0.0338)		(0.0496)		(0.0496)	
Observations	51,966	45,686	35,564	31,102	35,564	31,102
Number of sectors	18	18	7	7	7	7
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.396	0.400	0.493	0.496	0.493	0.496

Note: The dependent variable is labor productivity. ***, **, and * indicate 1%, 5%, and 10% significance, respectively. Country-sector clustered standard error is in parentheses.

[11] Since Eora national input-output tables are used to estimate forward and backward FDI spillover, seven sectors are used according to the sector classification of Eora National Input-Output Tables.

[12] For the same reason as footnote 11, 89 developing countries from 2007 to 2015 are used to estimate forward and backward FDI spillover.

[13] We focus on the results of IV methods for the FDI spillover effect to address the endogeneity from reverse causality.

The results estimated by the IV method are presented in Table 3. The estimated coefficient on horizontal FDI, which was negative and statistically significant in the OLS estimation, is positive but not statistically significant. In contrast, forward and backward FDI, which were not statistically significant in the OLS estimation, are positive and statistically significant. These results are consistent with our expectations and with Wang (2010), which examined the case of Canadian manufacturing firms.

In the case of the samples limited to Asia in Table 4, the coefficient of horizontal FDI is negative and statistically significant. This result, which is the same as Lu et al. (2017), which examined the case of Chinese manufacturing firms, probably reflects that horizontal FDI's competition effect that reduces value-added is greater than the spillover effects on domestic firms in the same sector in Asia. This, in turn, indicates foreign firms' significantly greater competitiveness compared with domestic firms. The coefficient of forward FDI is not statistically significant in Asia, while the effect of backward FDI spillover is significantly positive and much greater compared to the case for the world shown in Table 3. A finding that backward FDI spillover is particularly notable in Asia may indicate that there are many foreign firms engaged in assembling final products, and so domestic firms selling their parts and components to foreign firms acquire technology via business transactions. This may imply the importance of developing domestic parts and components producers, because they may be able to benefit from obtaining technology from foreign firms, particularly in Asia.

Table 3: IV Results, World

	(1)	(2)	(3)	(4)	(5)	(6)
	Horizontal FDI		Forward FDI		Backward FDI	
FDI	3.601	5.611	3.668***	4.174***	0.901**	0.688*
	(2.273)	(3.757)	(0.744)	(1.016)	(0.351)	(0.399)
lnsize	0.0244	0.0511***	0.0575***	0.0741***	0.0582***	0.0744***
	(0.0192)	(0.0117)	(0.00707)	(0.00742)	(0.00690)	(0.00722)
training	0.216***	0.200***	0.230***	0.220***	0.228***	0.219***
	(0.0178)	(0.0214)	(0.0191)	(0.0196)	(0.0187)	(0.0189)
qualitycert	0.360***	0.320***	0.385***	0.343***	0.380***	0.334***
	(0.0223)	(0.0258)	(0.0205)	(0.0212)	(0.0200)	(0.0205)
foreigntech	0.208***	0.200***	0.212***	0.198***	0.239***	0.230***
	(0.0235)	(0.0295)	(0.0261)	(0.0289)	(0.0248)	(0.0269)
foreign firm	–0.108		0.315***		0.313***	
	(0.261)		(0.0322)		(0.0315)	
Observations	51,925	45,656	35,564	31,102	35,564	31,102
Number of sectors	18	18	7	7	7	7
Underidentification test	9.381***	5.242**	373.738***	202.627***	1,180.778***	884.317***
Weak identification test	19.234	10.303	756.68	424.938	2,747.026	2,305.764
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable is labor productivity; ***, **, and * indicate 1%, 5%, and 10% significance, respectively. Robust standard error is in parentheses. In underidentification and weak identification tests, we report the Kleibergen-Paap rk LM statistic and Cragg-Donald Wald F statistic, respectively.

Table 4: IV Results, Asia

	(1)	(2)	(3)	(4)	(5)	(6)
	Horizontal FDI		Forward FDI		Backward FDI	
FDI	–1.322*	–1.939**	0.910	0.248	1.716***	1.896***
	(0.728)	(0.824)	(0.755)	(1.052)	(0.500)	(0.610)
lnsize	0.0383***	0.0497***	0.0323***	0.0537***	0.0326***	0.0508***
	(0.00888)	(0.00839)	(0.00907)	(0.00930)	(0.00898)	(0.00914)
training	0.196***	0.199***	0.226***	0.224***	0.221***	0.224***
	(0.0223)	(0.0226)	(0.0244)	(0.0246)	(0.0244)	(0.0244)
qualitycert	0.355***	0.305***	0.407***	0.356***	0.407***	0.361***
	(0.0244)	(0.0245)	(0.0258)	(0.0257)	(0.0259)	(0.0260)
foreigntech	0.199***	0.196***	0.283***	0.263***	0.273***	0.249***
	(0.0288)	(0.0306)	(0.0337)	(0.0347)	(0.0339)	(0.0351)
foreign firm	0.413***		0.278***		0.315***	
	(0.0920)		(0.0540)		(0.0541)	
Observations	24,208	21,890	19,429	17,510	19,429	17,510
Number of sectors	18	18	7	7	7	7
Underidentification test	58.277***	53.34***	276.131***	148.914***	1,153.185***	750.783***
Weak identification test	124.159	102.248	530.318	274.048	1,337.547	1,007.217
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable is labor productivity; ***, **, and * indicate 1%, 5%, and 10% significance, respectively. Robust standard error is in parentheses. In underidentification and weak identification tests, we report the Kleibergen-Paap rk LM statistic and Cragg-Donald Wald F statistic, respectively.

Tables 5 and 6 show the effects of firm-level absorptive capacity on FDI spillover.[14] The coefficients of all the interaction terms are positive and statistically significant, except GVC (column 5) in the case of world. These results indicate that a firm that belongs to a large firm, has internationally recognized quality certification, uses foreign technology, has training programs, and participates in GVC can benefit from FDI spillover. In the case of forward and backward FDI, the positive spillover is reinforced for a firm with absorptive capacity. These findings are consistent with earlier findings on the importance of a firm's absorptive capability for promoting FDI spillover. For the case of firms in Asia (Table 6), although the coefficient of FDI is negative in the cases of horizontal and forward FDI (columns 1 through 10), the sum of the coefficients of FDI and each interaction term are positive. These results indicate that the presence of high absorptive capacity leads to positive FDI spillover, because the positive impact of absorptive capacity overwhelms the negative effect of FDI. A comparison of the interaction terms in the case of the world and Asia reveals that the magnitudes of all the coefficients are larger in the case of Asia. This observation highlights the importance of firms' characteristics in determining the impacts of FDI spillover particularly for firms in Asia, leading to a policy recommendation to improve firms' capability of assimilating technology from foreign firms.

[14] In the first column of Tables 5–7, hfdi, ffdi, and bfdi indicate horizontal, forward, and backward FDI, respectively.

Table 5: Absorptive Capacity at Firm Level, World

	(1)	(2)	(3)	(4)	(5)
			Horizontal FDI		
FDI	1.794	10.29	8.518	11.44	9.767
	(1.402)	(7.229)	(5.223)	(7.261)	(6.648)
hfdi/ffdi/bfdi × plargefirm	0.992***				
	(0.125)				
hfdi/ffdi/bfdi × qualitycert		1.360***			
		(0.258)			
hfdi/ffdi/bfdi × foreigntech			1.054***		
			(0.190)		
hfdi/ffdi/bfdi × training				0.894***	
				(0.290)	
hfdi/ffdi/bfdi × gvc					0.534
					(0.446)
Observations	47,499	48,074	47,054	48,613	42,092
Number of sectors	18	18	18	18	18
Underidentification test	23.722***	3.109*	4.479**	3.638*	3.428*
Weak identification test	21.724	3.051	4.422	3.628	3.038
Country FE	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
	(6)	**(7)**	**(8)**	**(9)**	**(10)**
			Forward FDI		
FDI	7.049***	6.571***	5.275***	3.998***	4.689***
	(0.978)	(0.915)	(0.908)	(0.996)	(0.973)
hfdi/ffdi/bfdi × plargefirm	1.186***				
	(0.154)				
hfdi/ffdi/bfdi × qualitycert		2.139***			
		(0.124)			
hfdi/ffdi/bfdi × foreigntech			1.211***		
			(0.152)		
hfdi/ffdi/bfdi × training				1.371***	
				(0.0948)	
hfdi/ffdi/bfdi × gvc					1.584***
					(0.125)
Observations	32,034	33,005	32,049	33,299	27,222
Number of sectors	7	7	7	7	7
Underidentification test	246.064***	273.87***	271.966***	214.08***	223.513***
Weak identification test	265.573	297.588	292.635	221.905	201.495
Country FE	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
	(11)	**(12)**	**(13)**	**(14)**	**(15)**
			Backward FDI		
FDI	1.916***	1.073***	1.323***	0.399	0.587
	(0.400)	(0.391)	(0.386)	(0.408)	(0.414)
hfdi/ffdi/bfdi × plargefirm	1.302***				
	(0.149)				
hfdi/ffdi/bfdi × qualitycert		2.221***			
		(0.123)			
hfdi/ffdi/bfdi × foreigntech			1.675***		
			(0.166)		
hfdi/ffdi/bfdi × training				1.619***	
				(0.103)	
hfdi/ffdi/bfdi × gvc					1.737***
					(0.132)
Observations	32,034	33,005	32,049	33,299	27,222
Number of sectors	7	7	7	7	7
Underidentification test	838.428***	891.776***	931.383***	870.97***	825.736***
Weak identification test	1,114.135	1,170.403	1,253.139	1,150.24	954.047
Country FE	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable is labor productivity; ***, **, and * indicate 1%, 5%, and 10% significance, respectively. Robust standard error is in parentheses. In underidentification and weak identification tests, we report the Kleibergen-Paap rk LM statistic and Cragg-Donald Wald F statistic, respectively.

Table 6: Absorptive Capacity at Firm Level, Asia

	(1)	(2)	(3)	(4)	(5)
			Horizontal FDI		
FDI	–0.0801	–1.658**	–1.162	–1.143	–0.998
	(0.773)	(0.821)	(0.803)	(0.844)	(0.806)
hfdi/ffdi/bfdi × plargefirm	1.364***				
	(0.267)				
hfdi/ffdi/bfdi × qualitycert		2.251***			
		(0.204)			
hfdi/ffdi/bfdi × foreigntech			1.254***		
			(0.223)		
hfdi/ffdi/bfdi × training				1.796***	
				(0.183)	
hfdi/ffdi/bfdi × gvc					1.410***
					(0.246)
Observations	22,993	22,665	22,372	22,796	17,996
Number of sectors	18	18	18	18	18
Underidentification test	60.094***	53.097***	55.612***	50.359***	57.072***
Weak identification test	58.274	50.894	52.802	48.716	43.421
Country FE	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
	(6)	**(7)**	**(8)**	**(9)**	**(10)**
			Forward FDI		
FDI	–0.253	–0.114	–0.857	–0.358	–0.216
	(1.014)	(1.040)	(1.040)	(1.004)	(0.927)
hfdi/ffdi/bfdi × plargefirm	1.506***				
	(0.268)				
hfdi/ffdi/bfdi × qualitycert		2.424***			
		(0.201)			
hfdi/ffdi/bfdi × foreigntech			1.705***		
			(0.240)		
hfdi/ffdi/bfdi × training				1.919***	
				(0.180)	
hfdi/ffdi/bfdi × gvc					1.618***
					(0.245)
Observations	18,343	18,120	17,863	18,195	13,547
Number of sectors	7	7	7	7	7
Underidentification test	154.739***	151.112***	152.015***	158.559***	181.641***
Weak identification test	143.982	138.35	139.851	147.239	136.984
Country FE	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
	(11)	**(12)**	**(13)**	**(14)**	**(15)**
			Backward FDI		
FDI	1.973***	1.195**	1.769***	1.303**	1.678**
	(0.586)	(0.584)	(0.615)	(0.595)	(0.696)
hfdi/ffdi/bfdi × plargefirm	1.835***				
	(0.322)				
hfdi/ffdi/bfdi × qualitycert		2.953***			
		(0.248)			
hfdi/ffdi/bfdi × foreigntech			2.131***		
			(0.308)		
hfdi/ffdi/bfdi × training				2.447***	
				(0.221)	
hfdi/ffdi/bfdi × gvc					2.425***
					(0.344)
Observations	18,343	18,120	17,863	18,195	13,547
Number of sectors	7	7	7	7	7
Underidentification test	829.531***	801.37***	777.717***	530.102***	584.353***
Weak identification test	536.463	525.195	512.824	410.75	309.681
Country FE	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable is labor productivity; ***, **, and * indicate 1%, 5%, and 10% significance, respectively. Robust standard error is in parentheses. In underidentification and weak identification tests, we report the Kleibergen-Paap rk LM statistic and Cragg-Donald Wald F statistic, respectively.

Table 7 shows the results of estimation of the impact of country-specific absorptive capacity on three types of FDI spillover: horizontal, forward, and backward. All of the estimated coefficients are positive and statistically significant except three: education, in the cases of forward and backward FDI, and ipr in forward FDI, all of which are statistically insignificant. These findings are consistent with our expectation and indicate the importance of agglomeration, a free and open business environment, an open financial market, and a well-protected intellectual property rights environment for the promotion and acceleration of FDI spillovers. The finding of the importance of agglomeration highlights the generation of external economies by agglomeration, which justifies government support for the construction of industrial clusters and estates. The finding on a free and open business environment indicates the importance of competition in obtaining FDI spillover, while the finding on open financial market indicates the importance of financial resources in promoting FDI spillover. The finding on intellectual property right (IPR) protection confirms the importance of providing an environment where IPR is fully protected in order for a foreign firm to use technology actively without worrying about the misuse of its technology. The unexpected result for education may be attributable to the notion that it is not a high level of education but technical training that is effective in assimilating technology. This observation is consistent with an earlier finding that training programs provided by firms promote technology spillover.

We examined how the geographical distance between foreign and domestic firms affects FDI spillover using the firm's regional (location) information included in the World Bank's Enterprise Surveys. We estimated equation 1 using region-sector level FDI (FDI_{srt}) instead of country-sector level FDI (FDI_{sct}). In other words, we measure FDI_{srt} by the extent of foreign presence in sector *s* in region *r* at time *t*, defined as the sales share of foreign firms in total sales in sector *s* in region *r*. As for the calculation of vertical FDI variables at region-sector level, since regional input-output tables are not available, we calculated vertical FDI with forward and backward coefficients (α_{sk} and β_{sm} in equations 3 and 4, respectively) taken from Eora national input-output tables, assuming that the transactional relationships between sectors in the region are the same as those in the country. Table 8 shows the estimated results. We expect the coefficient of each FDI to be greater than those in Table 3 based on the assumption that the shorter the geographical distance between foreign firms and domestic firms, the greater the FDI spillover. The coefficient of horizontal FDI is negative due to the greater competition effects between foreign firms and domestic firms at region level compared to country level. The coefficient on forward FDI is negative but not significant, while the coefficient on backward FDI is positive and statistically significant as expected. A comparison of the results in Table 8 and Table 3 appears to indicate that geographical proximity at region level is not so important in vertical FDI spillover. This is because forward FDI spillover, observed at country level in Table 3, is not observed here. Backward FDI spillover is observed in Table 8 but the magnitude is significantly smaller compared to the result in Table 3. These findings seem to indicate that it is business relationship that is important in FDI spillover, and geographical proximity at region level is not so important.

Table 7: Absorptive Capacity at Country Level

	(1)	(2)	(3)	(4)	(5)	(6)
			Horizontal FDI			
FDI	2.626***	5.492***	10.14***	12.24***	0.103	9.540**
	(0.826)	(0.973)	(3.214)	(2.738)	(0.683)	(4.273)
hfdi/ffdi/bfdi × agglom	0.0193***					
	(0.00230)					
hfdi/ffdi/bfdi × tradeopen		0.0115***				
		(0.00254)				
hfdi/ffdi/bfdi × businesreg			1.009***			
			(0.144)			
hfdi/ffdi/bfdi × finanopen				0.295***		
				(0.0552)		
hfdi/ffdi/bfdi × education					0.0651***	
					(0.00855)	
hfdi/ffdi/bfdi × ipr						0.970***
						(0.212)
Observations	41,090	48,730	41,322	41,218	33,821	45,421
Number of sectors	18	18	18	18	18	18
Underidentification test	71.769***	93.207***	28.988***	29.634***	57.553***	20.757***
Weak identification test	64.209	72.831	22.852	24.415	50.189	15.711
Subregion FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
	(7)	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
			Forward FDI			
FDI	0.227	–0.000580	5.902***	2.477***	–0.484	13.78***
	(0.383)	(0.596)	(1.137)	(0.653)	(0.546)	(2.073)
hfdi/ffdi/bfdi × agglom	0.0302***					
	(0.00267)					
hfdi/ffdi/bfdi × tradeopen		0.0282***				
		(0.00232)				
hfdi/ffdi/bfdi × businesreg			0.488***			
			(0.0924)			
hfdi/ffdi/bfdi × finanopen				0.334***		
				(0.0277)		
hfdi/ffdi/bfdi × education					0.00660	
					(0.00769)	
hfdi/ffdi/bfdi × ipr						–0.313
						(0.214)
Observations	29,089	33,609	33,403	33,338	25,550	31,939
Number of sectors	7	7	7	7	7	7
Underidentification test	593.137***	549.692***	368.62***	590.812***	473.328***	217.306***
Weak identification test	573.784	309.416	211.314	319.228	210.265	94.099
Subregion FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
	(13)	**(14)**	**(15)**	**(16)**	**(17)**	**(18)**
			Backward FDI			
FDI	1.913***	3.261***	0.153	6.105***	3.611***	–0.751
	(0.459)	(0.466)	(0.787)	(0.452)	(0.608)	(0.832)
hfdi/ffdi/bfdi × agglom	0.0266***					
	(0.00247)					
hfdi/ffdi/bfdi × tradeopen		0.0361***				
		(0.00284)				
hfdi/ffdi/bfdi × businesreg			0.926***			
			(0.0841)			
hfdi/ffdi/bfdi × finanopen				0.424***		
				(0.0416)		
hfdi/ffdi/bfdi × education					–0.00374	
					(0.0115)	
hfdi/ffdi/bfdi × ipr						1.476***
						(0.107)
Observations	29,089	33,609	33,403	33,338	25,550	31,939
Number of sectors	7	7	7	7	7	7
Underidentification test	524.257***	659.642***	517.683***	606.561***	746.895***	421.147***
Weak identification test	860.78	911.371	756.083	788.957	1,056.374	633.514
Subregion FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable is labor productivity; ***, **, and * indicate 1%, 5%, and 10% significance, respectively. Robust standard error is in parentheses. In underidentification and weak identification tests, we report the Kleibergen-Paap rk LM statistic and Cragg-Donald Wald F statistic, respectively.

Table 8: IV Results (Domestic FDI Spillover)

	(1)	(2)	(3)	(4)	(5)	(6)
	Horizontal FDI		Forward FDI		Backward FDI	
FDI	–2.375**	–2.212*	–0.199	–0.291	0.602***	0.534**
	(1.118)	(1.240)	(0.260)	(0.305)	(0.229)	(0.268)
lnsize	0.0794***	0.0779***	0.0420***	0.0567***	0.0420***	0.0588***
	(0.0148)	(0.00928)	(0.00834)	(0.00875)	(0.00728)	(0.00758)
training	0.214***	0.224***	0.240***	0.237***	0.248***	0.246***
	(0.0187)	(0.0208)	(0.0233)	(0.0239)	(0.0200)	(0.0204)
qualitycert	0.366***	0.320***	0.389***	0.345***	0.394***	0.352***
	(0.0200)	(0.0198)	(0.0244)	(0.0253)	(0.0213)	(0.0220)
foreigntech	0.211***	0.196***	0.217***	0.243***	0.232***	0.255***
	(0.0237)	(0.0245)	(0.0304)	(0.0330)	(0.0264)	(0.0287)
foreign firm	0.926***		0.264***		0.265***	
	(0.297)		(0.0371)		(0.0327)	
Observations	43,168	37,780	22,636	19,748	30,589	26,641
Number of sectors	18	18	7	7	7	7
Underidentification test	34.412***	30.507***	1255.464***	957.094***	975.469***	756.831***
Weak identification test	40.24	31.978	5,015.014	4,084.582	8,000.719	6,661.216
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Prefecture FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable is labor productivity; ***, **, and * indicate 1%, 5%, and 10% significance, respectively. Robust standard error is in parentheses. In underidentification and weak identification tests, we report the Kleibergen-Paap rk LM statistic and Cragg-Donald Wald F statistic, respectively.

5. CONCLUSIONS

The paper has attempted to identify the FDI spillover effects in developing countries and to investigate the importance of the absorptive capacity of a firm and a country in realizing and facilitating FDI spillover. It used data obtained from the World Bank's Enterprise Surveys for 107 countries from 2007 to 2020.

We found that firms in developing countries do not benefit from horizontal FDI but benefit from forward and backward FDI. In other words, there are no horizontal FDI spillover effects, but there are vertical spillover effects in developing countries. As regards horizontal FDI, competition for domestic firms from foreign firms in the same sector could increase domestic firms' productivity by forcing them to improve their production technology to survive in the market. This is a case of positive spillover. Domestic firms may experience a decline in productivity, or negative spillover, if competitive foreign firms force them to reduce production. Our finding on horizontal FDI showed that neither of these two opposing effects overwhelms the other, indicating no FDI spillover.

We found that domestic firms benefit from horizontal, forward, and backward FDI by improving their absorptive capacity and if the absorptive capacity of the host country improves. Specifically, we found that belonging to a large firm, having internationally recognized quality certification, using foreign technology, having training programs, and participating in GVC enables a domestic firm to realize or accelerate FDI spillover. As for the absorptive capacity of host countries, we found some variations in the results among three types of FDI spillover, i.e., horizontal, forward, and backward. The findings that are common for the three types of spillover indicate that firms can

increase their benefit from FDI spillover in a country with an open trade and financial environment, a free business environment, and a high level of agglomeration of firms.

Based on our findings, we offer the following recommendations for domestic firms and governments. For firms, research and development activities need to be promoted so that firms may acquire an internationally recognized quality certificate. Firms are also advised to run training programs to improve workers' skills, and they are advised to participate in GVCs. These activities will promote FDI spillover by improving the firm's capacity to absorb foreign technology.

Turning to the recommendation to the government, establishing and maintaining open trade and financial regimes and ensuring a competitive business environment are very important. To achieve these objectives, governments are advised to participate in international rules/agreements such as free trade agreements (FTAs), which will exert external competitive pressure on domestic firms from imports and ensure the availability of foreign financial resources. Protection of IPR is highly recommended by complying with international rules such as the World Trade Organization Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), the World Intellectual Property Organization (WIPO), and FTAs with IPR chapters. Developing clusters is also recommended—for example, by constructing industrial zones.

In order to realize these recommendations, governments, and particularly political leaders, have to recognize the importance of assimilating foreign technology to promote economic development and growth. Political leaders and policymakers with that recognition need to persuade the general public, with assistance from international organizations such as the Asian Development Bank and the World Bank, to gain support for needed policies by presenting successful cases, which can be found in many East Asian developing countries.

APPENDIX

Appendix Table 1: Sample Countries and Number of Sample Firms

No	Country Name	Included In	# of Firms	No	Country Name	Included In	# of Firms
1	Afghanistan	HFDI, FFDI, BFDI	46	55	Mongolia	HFDI, FFDI, BFDI	319
2	Angola	HFDI, FFDI, BFDI	115	56	Mozambique	HFDI, FFDI, BFDI	489
3	Albania	HFDI, FFDI, BFDI	294	57	Mauritania	HFDI, FFDI, BFDI	35
4	Argentina	HFDI, FFDI, BFDI	1,161	58	Malawi	HFDI, FFDI, BFDI	94
5	Armenia	HFDI, FFDI, BFDI	345	59	Malaysia	HFDI, FFDI, BFDI	481
6	Azerbaijan	HFDI, FFDI, BFDI	182	60	Namibia	HFDI, FFDI, BFDI	54
7	Burundi	HFDI, FFDI, BFDI	54	61	Nigeria	HFDI, FFDI, BFDI	646
8	Burkina Faso	HFDI, FFDI, BFDI	66	62	Nicaragua	HFDI, FFDI, BFDI	165
9	Bangladesh	HFDI, FFDI, BFDI	1,044	63	Nepal	HFDI, FFDI, BFDI	213
10	Bulgaria	HFDI, FFDI, BFDI	500	64	Pakistan	HFDI, FFDI, BFDI	453
11	Bosnia and Herzegovina	HFDI, FFDI, BFDI	265	65	Panama	HFDI, FFDI, BFDI	59
12	Belarus	HFDI, FFDI, BFDI	434	66	Peru	HFDI, FFDI, BFDI	1,076
13	Brazil	HFDI, FFDI, BFDI	1,008	67	Philippines	HFDI, FFDI, BFDI	1,482
14	Bhutan	HFDI, FFDI, BFDI	61	68	Papua New Guinea	HFDI, FFDI, BFDI	22
15	Botswana	HFDI, FFDI, BFDI	68	69	Poland	HFDI, FFDI, BFDI	708
16	Chile	HFDI, FFDI, BFDI	603	70	Romania	HFDI, FFDI, BFDI	720
17	People's Republic of China	HFDI, FFDI, BFDI	1,635	71	Russian Federation	HFDI, FFDI, BFDI	2,305
18	Côte d'Ivoire	HFDI, FFDI, BFDI	191	72	Senegal	HFDI, FFDI, BFDI	347
19	Cameroon	HFDI, FFDI, BFDI	141	73	Sierra Leone	HFDI, FFDI, BFDI	60
20	Democratic Republic of the Congo	HFDI, FFDI, BFDI	233	74	El Salvador	HFDI, FFDI, BFDI	357
21	Colombia	HFDI, FFDI, BFDI	1,071	75	Serbia	HFDI, FFDI, BFDI	286
22	Costa Rica	HFDI, FFDI, BFDI	217	76	South Sudan	HFDI, FFDI, BFDI	57
23	Djibouti	HFDI, FFDI, BFDI	53	77	Tajikistan	HFDI, FFDI, BFDI	238
24	Dominican Republic	HFDI, FFDI, BFDI	160	78	Tunisia	HFDI, FFDI, BFDI	482
25	Ecuador	HFDI, FFDI, BFDI	167	79	Turkey	HFDI, FFDI, BFDI	2,277
26	Egypt	HFDI, FFDI, BFDI	2,549	80	United Republic of Tanzania	HFDI, FFDI, BFDI	217
27	Ethiopia	HFDI, FFDI, BFDI	496	81	Uganda	HFDI, FFDI, BFDI	218
28	Gabon	HFDI, FFDI, BFDI	21	82	Ukraine	HFDI, FFDI, BFDI	1,658
29	Ghana	HFDI, FFDI, BFDI	496	83	Uruguay	HFDI, FFDI, BFDI	310
30	Guatemala	HFDI, FFDI, BFDI	325	84	Uzbekistan	HFDI, FFDI, BFDI	769
31	Honduras	HFDI, FFDI, BFDI	155	85	Venezuela	HFDI, FFDI, BFDI	50
32	Croatia	HFDI, FFDI, BFDI	306	86	Viet Nam	HFDI, FFDI, BFDI	1,257
33	Indonesia	HFDI, FFDI, BFDI	1,927	87	Yemen	HFDI, FFDI, BFDI	165
34	India	HFDI, FFDI, BFDI	6,747	88	South Africa	HFDI, FFDI, BFDI	817
35	Iraq	HFDI, FFDI, BFDI	430	89	Zambia	HFDI, FFDI, BFDI	634
36	Jamaica	HFDI, FFDI, BFDI	60	90	Benin	Only HFDI	58
37	Jordan	HFDI, FFDI, BFDI	322	91	Bolivia	Only HFDI	156
38	Kazakhstan	HFDI, FFDI, BFDI	912	92	Georgia	Only HFDI	309
39	Kyrgyz Republic	HFDI, FFDI, BFDI	255	93	Guinea	Only HFDI	15
40	Lao People's Democratic Republic	HFDI, FFDI, BFDI	292	94	Gambia	Only HFDI	62
41	Lebanon	HFDI, FFDI, BFDI	420	95	Kenya	Only HFDI	679
42	Liberia	HFDI, FFDI, BFDI	80	96	Cambodia	Only HFDI	108
43	Sri Lanka	HFDI, FFDI, BFDI	321	97	Mauritius	Only HFDI	120
44	Lesotho	HFDI, FFDI, BFDI	107	98	Niger	Only HFDI	26
45	Lithuania	HFDI, FFDI, BFDI	136	99	Paraguay	Only HFDI	159
46	Latvia	HFDI, FFDI, BFDI	132	100	Rwanda	Only HFDI	101
47	Morocco	HFDI, FFDI, BFDI	473	101	Solomon Islands	Only HFDI	34
48	Republic of Moldova	HFDI, FFDI, BFDI	301	102	Suriname	Only HFDI	42
49	Madagascar	HFDI, FFDI, BFDI	116	103	Eswatini	Only HFDI	52
50	Mexico	HFDI, FFDI, BFDI	908	104	Chad	Only HFDI	55
51	North Macedonia	HFDI, FFDI, BFDI	298	105	Togo	Only HFDI	36
52	Mali	HFDI, FFDI, BFDI	442	106	Thailand	Only HFDI	584
53	Myanmar	HFDI, FFDI, BFDI	601	107	Timor-Leste	Only HFDI	18
54	Montenegro	HFDI, FFDI, BFDI	90				

Note: 107 developing countries are used for horizontal FDI spillover, and 89 developing countries are used for forward and backward FDI spillover. High-income countries are excluded from the dataset based on the World Bank list of economies (high income: 2007 GNI per capita, $11,456 or more).

Appendix Table 2: Sample Sectors

Enterprise Surveys		Eora National Input-Output Tables	
No	**Sector Name**	**No**	**Sector Name**
1	Food	1	Food and Beverages
2	Tobacco		
3	Textiles	2	Textiles and Wearing Apparel
4	Garments		
5	Leather		
6	Wood	3	Wood and Paper
7	Paper		
8	Publishing, Printing, and Recorded Media		
9	Refined Petroleum Products	4	Petroleum, Chemical and Non-Metallic Mineral Products
10	Chemicals		
11	Plastic and Rubber		
12	Non Metallic Mineral Products		
13	Basic Metals	5	Metal Products
14	Fabricated Metal Products		
15	Machinery and Equipment	6	Electrical and Machinery
16	Electronics		
17	Precision Instruments		
18	Transport Machines	7	Transport Equipment

Note: As mentioned in section 3, 18 sector classification of Enterprise Surveys is for horizontal FDI, and 7 sector classification of Eora national input-output tables is for forward and backward FDI.

Appendix Table 3: Basic Statistics for Horizontal FDI Spillover

Variable	Obs	Mean	Std. Dev.	Min	Max
lnLP	51,966	5.3022	1.8929	–9.1025	20.0712
hfdi	51,966	0.2601	0.2767	0	1
lnsize	51,966	3.6028	1.4336	0	11.0666
training	51,966	0.3700	0.4828	0	1
qualitycert	51,966	0.3007	0.4586	0	1
foreigntech	51,966	0.1575	0.3643	0	1
foreign firm	51,966	0.1208	0.3260	0	1
hfdi × plargefirm	47,499	0.0304	0.1195	0	1.0000
hfdi × qualitycert	48,074	0.0547	0.1534	0	0.9999
hfdi × foreigntech	47,054	0.0324	0.1264	0	1.0000
hfdi × training	48,613	0.0818	0.1854	0	0.9999
hfdi × gvc	42,092	0.0548	0.1596	0	0.9999
hfdi × agglom	41,090	7.0982	12.1983	0	99.6133
hfdi × tradeopen	48,730	15.4912	20.5943	0	157.6642
hfdi × businessreg	41,322	1.4132	1.5885	0	8.0418
hfdi × finanopen	41,218	1.0658	1.5646	0	9.9865
hfdi × education	33,821	8.6460	11.2802	0	84.0633
hfdi × ipr	45,421	1.1329	1.2434	0	6.5911

Source: Authors' compilation.

Appendix Table 4: Basic Statistics for Forward and Backward FDI Spillovers

Variable	Obs	Mean	Std. Dev.	Min	Max
lnLP	35,564	5.3508	2.0219	-9.1025	20.0712
ffdi	35,564	0.2415	0.1935	0	0.9880
bfdi	35,564	0.2091	0.1669	0	0.8778
lnsize	35,564	3.6139	1.4381	0	11.0666
training	35,564	0.3831	0.4861	0	1
qualitycert	35,564	0.3176	0.4655	0	1
foreigntech	35,564	0.1569	0.3637	0	1
foreign firm	35,564	0.1255	0.3312	0	1
ffdi × plargefirm	32,034	0.0285	0.0933	0	0.9067
ffdi × qualitycert	33,005	0.0527	0.1172	0	0.8801
ffdi × foreigntech	32,049	0.0312	0.1025	0	0.9063
ffdi × training	33,299	0.0792	0.1452	0	0.9067
ffdi × gvc	27,222	0.0498	0.1256	0	0.8801
ffdi × agglom	29,089	6.6920	9.6918	0	78.1608
ffdi × tradeopen	33,609	14.3999	14.5182	0	91.8207
ffdi × businessreg	33,403	1.3710	1.1101	0	6.7721
ffdi × finanopen	33,338	0.9539	1.1741	0	7.7439
ffdi × education	25,550	7.4410	8.2308	0	50.8859
ffdi × ipr	31,939	1.1008	0.8581	0	4.5711
bfdi × plargefirm	32,034	0.0279	0.0902	0	0.8332
bfdi × qualitycert	33,005	0.0467	0.1078	0	0.8332
bfdi × foreigntech	32,049	0.0268	0.0885	0	0.8256
bfdi × training	33,299	0.0692	0.1311	0	0.8727
bfdi × gvc	27,222	0.0421	0.1077	0	0.8332
bfdi × agglom	29,089	5.8424	8.5442	0	77.8640
bfdi × tradeopen	33,609	13.1305	15.2392	0	129.7959
bfdi × businessreg	33,403	1.1865	0.9706	0	5.2679
bfdi × finanopen	33,338	0.8249	0.9824	0	6.5309
bfdi × education	25,550	6.6149	7.6000	0	62.1568
bfdi × ipr	31,939	0.9507	0.7534	0	4.3177

Source: Authors' compilation.

REFERENCES

Alfaro, L., A. Chanda, S. Kalemli-Ozcan, and S. Sayek. (2004). “FDI and economic growth: the role of domestic financial markets.” *Journal of International Economics*, 64(1), 89–112.

Alguacil, M., A. Cuadros, and V. Orts. (2011). “Inward FDI and growth: The role of macroeconomic and institutional environment.” *Journal of Policy Modeling*, 33(3), 481–496.

Bengoa, M., and B. Sanchez-Robles. (2003). “Foreign direct investment, economic freedom and growth: New evidence from Latin America.” *European Journal of Political Economy*, 19(3), 529–545.

Blalock, G., and P. J. Gertler. (2009). “How firm capabilities affect who benefits from foreign technology.” *Journal of Development Economics*, 90(2), 192–199.

Borensztein, E., J. De Gregorio, and J. W. Lee. (1998). “How does foreign direct investment affect economic growth?” *Journal of International Economics*, 45(1), 115–135.

Castellani, D., and A. Zanfei. (2007). “Multinational firms and productivity spillovers: The role of firms’ heterogeneity.” *Progress in International Business Research*, 1, 33–60.

Damijan, J. P., and M. Knell. (2005). “How important is trade and foreign ownership in closing the technology gap? Evidence from Estonia and Slovenia.” *Review of World Economics*, 141(2), 271–295.

Damijan, J. P., M. Rojec, B. Majcen, and M. Knell. (2013). “Impact of firm heterogeneity on direct and spillover effects of FDI: Micro evidence from ten transition countries.” *Journal of Comparative Economics*, 41, 895–922.

Dogan, E., K. N. Wong, and M. M. Yap. (2017). “Vertical and horizontal spillovers from foreign direct investment: Evidence from Malaysian manufacturing.” *Asian Economic Papers*, 16(3), 158–183.

Durham, J. B. (2004). “Absorptive capacity and the effects of foreign direct investment and equity foreign portfolio investment on economic growth.” *European Economic Review*, 48(2), 285–306.

Farole, T., and D. E. Winkler. (2012). “Foreign firm characteristics, absorptive capacity and the institutional framework: The role of mediating factors for FDI spillovers in low-and middle-income countries.” World Bank Policy Research Working Paper No. 6265.

Girma, S., Y. Gong, and H. Görg. (2005). “Can you teach old dragons new tricks? FDI and innovation activity in Chinese state-owned enterprises.” Research Paper No. 2005/34, Leverhulme Centre for Research on Globalisation and Economic Policy, University of Nottingham, Nottingham.

Glass, A., and K. Saggi. (1998). “International technology transfer and the technology gap.” *Journal of Development Economics*, 55, 369–398.

Gorodnichenko, Y., J. Svejnar, and K. Terrell (2006). “Vertical and horizontal spillovers: Do institutions matter?” Mimeo, Michigan University.

———. (2014). “When does FDI have positive spillovers? Evidence from 17 transition market economies.” *Journal of Comparative Economics*, 42(4), 954–969.

Haskel, J. E., S. Pereira, and M. J. Slaughter. (2007). “Does inward foreign direct investment boost the productivity of domestic firms?” *The Review of Economics and Statistics*, 89(3), 482–496.

Javorcik, B. S. (2004). “Does foreign direct investment increase the productivity of domestic firms? In search of spillovers through backward linkages.” *American Economic Review*, 94(3), 605–627.

Keller, W. (2004). “International technology diffusion.” *Journal of Economic Literature*, 42(3), 752–782.

Keller, W., and S. R. Yeaple. (2009). “Multinational enterprises, international trade, and productivity growth: Firm-level evidence from the United States.” *The Review of Economics and Statistics*, 91(4), 821–831.

Lesher, M., and S. Miroudot. (2008). “FDI spillovers and their interrelationships with trade.” OECD Trade Policy Working Paper No. 80.

Lu, Y., Z. Tao, and L. Zhu. (2017). “Identifying FDI spillovers.” *Journal of International Economics*, 107, 75–90.

Newman, C., J. Rand, T. Talbot, and F. Tarp. (2015). “Technology transfers, foreign investment and productivity spillovers.” *European Economic Review*, 76, 168–187.

Nicolini, M., and L. Resmini. (2006). “The impact of MNEs on domestic firms in CEECs: A micro-econometric approach.” Mimeo, ISLA, Bocconi University, Milan.

Rodrik, D. (1999). *The new global economy and developing countries: Making openness work*. Policy Essay No. 24. Overseas Development Council, Washington, DC.

Rojec, M., and M. Knell, (2018). “Why is there a lack of evidence on knowledge spillovers from foreign direct investment?” *Journal of Economic Surveys*, 32(3), 579–612.

Wang, Y. (2010). “FDI and productivity growth: The role of inter-industry linkages.” *Canadian Journal of Economics*, 43(4), 1243–1272.