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Abstract

Technology spillover induced by foreign direct investment has been proved to be an important channel to boost the productivity growth of local firms in the host country, especially in the context of developing economies. However, the empirical evidence remains inconsistent as to what extent the scale of spillover is affected by the productivity gap between foreign investors and local firms. This paper attempts to make clear such mechanism by applying Vietnamese firm-level data. Focusing on Asian investors, we show that the relationship between the productivity gap and vertical spillover takes an inverted-U shape. To be specific, we use stepwise chow test to decide on the cutoff value of total factor productivity (TFP) as the grouping criteria, and divide investors into low, middle and high-TFP groups. The results reveal that local suppliers in Vietnam can benefit the most from the Asian investors with middle-level TFP, whereas the benefits from the other two groups fade away. The finding is strongly robust even after we control the other spillover-influential factors such as firms' own effort to innovate, foreign firms' ownership, country and industry heterogeneity, and no matter whether we use stochastic frontier or Levinsohn & Petrin measurement of TFP. It thus provides novel evidence that investors with advanced technology do not necessarily diffuse their know-how to local partners. This implies it is important that both Vietnamese local firms and investors with superior technology work in the same direction to stimulate more corporations with each other.

Keywords: technology spillover, productivity gap, firm-level data, Vietnam.

JEL Classification Numbers: D22, F21, F64, Q56.

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1 Introduction

Empirical studies to explore the relationship between the technology gap and spillover at the macro-level show contradictory results. Li and Liu (2005), discover that a higher-technology gap (measured as per capita income ratio) between the domestic economy and the technology leader reduces the positive effect from FDI on income growth. However, Baltabaev (2014) indicates that technology gap can enhance the spillover from FDI. This has been supported by Shen et al. (2010) who find that high income levels promote the positive impact of FDI. In the meantime, micro-level studies also yield mixed findings. Liu et al. (2000), for example, find a negative significant impact from the technology gap in the UK manufacturing industry. Blalock and Gertler (2009), on the other hand, demonstrate that Indonesian manufacturing firms with larger technological gaps gain from FDI. They also show that firms with greater absorptive capacity benefit more from downstream FDI, implying the necessity to control firms' own absorbing effort.

Based on previous literature, this study takes a step further to measure the spillover impact from foreign investors by controlling the level of technology gap. To be specific, we group foreign firms by the TFP level while taking into account their geographical heterogeneity and ownership difference. We use different thresholds as grouping criteria and divide investors into low-, middle- and high-TFP ones. We pay special attention to the vertical linkage because it is most likely to occur (Blalock and Gertler, 2008). However, to take into account the possible influence from the foreign competitors in the same industry, we include horizontal spillover index in the estimation as well. After controlling firms' own effort to absorb technology and other firm-industry-year fixed effects, we show a robust result that local suppliers in Vietnam experience the most productivity gains in the presence of downstream Asian partners who have relatively similar TFP as the suppliers themselves, or in other words, the "peers". It is thus in contrast with some of the existing studies which indicate that only a larger technology gap between upstream local firms and downstream foreign investors will lead to greater spillover (Findlay, 1978; Wang and Blomstrom, 1992;

Borensztein et al., 1998).

This study is positioned as the first paper to apply firm-level data to verify how the level of technology gap matters for spillover realization in the context of Vietnam. This paper contributes to the previous literature by empirically presenting the consistent and robust result to make clear the relationship. The rest of the paper will be organized as follows: Section 2 describes the situation of inward FDI in Vietnam and why it is important to investigate this issue in Vietnam. Section 3 summarizes the previous literature concerning the technology gap and spillover effect of FDI. Section 4 describes the data and estimation strategy. Section 5 presents the results, and examines the robustness. Section 6 concludes.

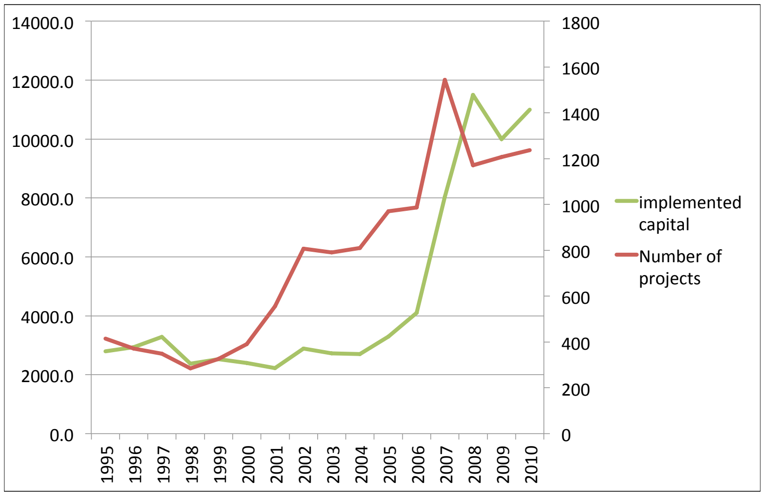
2 Foreign direct investment in Vietnam

Vietnam is an ideal setting for us to investigate the relationship between FDI and technology spillover, for several reasons. To begin with, Vietnam has experienced remarkable economic growth mainly due to two major events—the adoption of a major economic reform called Doi Moi in 1986, and the accession to the World Trade Organization (WTO) in 2006. According to the "Vietnam country profile" made by Library of Congress Federal Research Division, a high growth rate of around 7% was observed from the late 1990s, and this period is characterized as being a period of rapid increase in inward FDI to the country (see Figure 3-2). By year 2000, China had been the world ' s most popular destination for FDI for a long time, however, ever since then, the trend has shifted to emerging South-East Asian countries, among which Vietnam is becoming one of the most successful countries in the region in attracting FDI across the world both because of its labor abundance and low wage rate[1] and the success of Doi Moi in liberalizing trade and investment.

In the meantime, for most of the foreign investors who are entering the Vietnamese

[1]For example, in the apparel industry, the average wage in Vietnam is approximately half that in China (the Wall Street Journal, May 1st, 2013). Also, Samsung is shifting their production base to Vietnam in order to maintain profit margins by saving labor costs as growth in sales of high-end handsets has slowed down, according to a Bloomberg report in December 2013 (Lee and Folkmanis, 2013).

Figure 1: Number of FDI projects and implemented FDI (Bill. Dongs) in Vietnam.

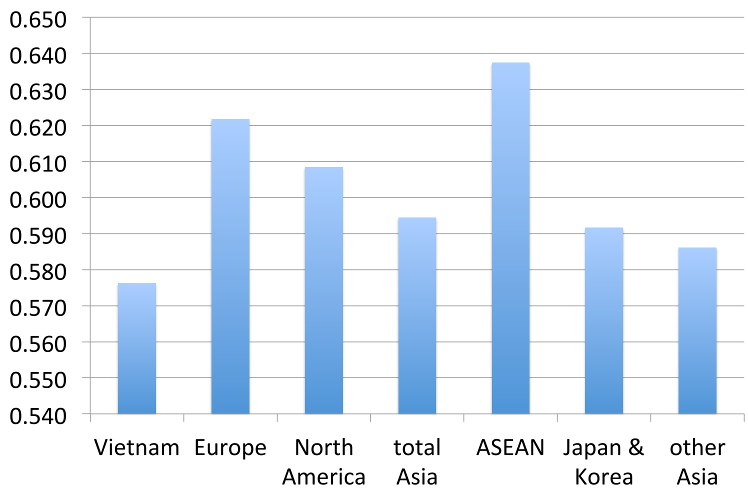


Source: General Statistics Office, Vietnam.

market, they have far better technology than their Vietnamese counterparts do, in term of TFP. Ni et al. (2015) has shown that the average TFP levels of Asian, European and North American firms are all higher than that of the Vietnamese firms (See Figure 2), and such technology disadvantage gives Vietnamese firms more potential to catch up. Since technology spillover from foreign investors turns out to be an important channel to boost the productivity of domestic firms in Vietnam (Nguyen, 2008), Vietnamese government has committed to improve its investment environment and tries to use more policy tools[2] to attract FDI. However, the targets are not limited to foreign investors with advanced technology. For instance, the newly passed 2005 Investment law in Vietnam distinguishes the sectors in which FDI is encouraged, including both labor-intensive and high-tech industries. Such actions increase the uncertainty as what kind of FDI will enter and lead to random technology gap between new foreign investors and domestic firms, which leaves room for us to explore how the spillover can be affected by technology differences. The findings can thus provide possible implications for the decision-makers in Vietnam to adjust further policies.

[2]Policies' influence on the technology spillover might also be substantial, it is beyond the scope of discussion in this paper.

Figure 2: Average firm TFP by region.



Source: Ni et al. (2015).

3 Conceptual framework and literature review

To investigate how the productivity gap can affect the level of technology spillover that local suppliers receive, there are several questions that need to be answered: How can technology spillover be measured, and how is it determined? In terms of vertical spillover, why does the technology gap matter?

The technology spillover effect has always been a noticeable topic regarding the impact of FDI[3]. The prevailing perception of such effect has been based on domestic firms' productivity, and in empirical works mixed results have been observed concerning the spillover effect, as in the survey of Smeets (2008). However, the phenomenon might be induced by factors such as the channels for transferring technology via FDI and local firms' capabilities to absorb the knowledge. With regard to the former, as suggested in Saggi (2002), there are three potential channels of spillover: demonstration effect, labor switching and vertical linkage.

1. Demonstration effect. Local firms may imitate multinational firms (MNEs) because

[3]Rigorously speaking, we are defining the technology spillover as the knowledge transmission between firms with different ownership, in comparison to the one that occurs in between a firm's headquarter and its oversea subsidiaries. In Saggi (2002), spillover alone has been defined as the pure externalities accompanying FDI, such as facilitation of technology adoption.

it is too costly to adopt the new technology owned by MNEs. Through this process, the set of technologies available to local firms can be expanded, leading to a positive externality. But in the meantime, the incremental technologies may also increase the competition. If the competition effect outweighs the positive influence, the total net effect of the technology spillover due to FDI will turn out to be negative, which is known as the "crowding out" or "market stealing effect" (Aitken and Harrison, 1999; Caves, 1996; Sleuwaegen and Backer, 2003). This effect is observed mostly in the same industry where competition is more common and addressed as "horizontal spillover".

2. Labor switching. The knowledge embodied by the workers can transmit across firms through physical movement. Those who have worked in multinational firms will bring the knowledge to the next employer, and such intangible asset can also become a source of technology spillover. However, since it is difficult to track the individuals' carry-on from old to new employers and we focus mainly on the spillover effect derived from firms' interaction, we will not emphasize on this factor in the current study.

3. Vertical linkage. This is the most widely recognized channel through which the technology spillover might occur. During the process when foreign investors in the downstream industries source from the local suppliers in the upstream industries, the know-how as well as the demanding requirements by foreign firms will push up the productivity level of the suppliers, resulting in the backward vertical spillover. Evidence of technology transfer through vertical linkage is well observed. For example, Blomstrom and Kokko (1998), Gorg and Greenaway (2004) all find positive vertical spillover. Javorcik (2004) comes up with similar results in Lithuania. Recent literature to support the positive spillover argument includes Blalock and Gertler (2008), Indonesia/ Javorcik and Li (2013), Romania. Combining the three factors together, since vertical linkage is most likely to benefit local firms, it will be of the utmost interest in our study.

For the spillover to take effect, apart from the supply side of technology as mentioned above, we also need to look into the demand side catered for the technology upgrading.

That is, if a local supplier wants to benefit from the advanced technology owned by foreign investors, there are two major determinants: the supplier's own effort to innovate, such as the proportion of expenditure on R&D to the total revenue, and its compatibility to absorb the technology, or the "capability to catch up". Especially for the latter, it to a great extent determines the diffusion level a local firm might receive and has been explored by a number of previous studies. Carluccio and Fally (2013) provide a decent theoretical explanation on the mechanism of how compatibility affects technology spillover: The more compatible a supplier is to adopt the foreign technology, the wider the choice set of compatible intermediate inputs will be, thus reducing the production unit cost and driving up the productivity of the supplier. Such variation becomes the source of difference in technology spillover effect. More practically, technology gap is used to capture the incompatibility between local suppliers and foreign investors in the downstream industries. Findlay (1978), Wang and Blomstrom (1992), Borensztein et al. (1998) all theoretically show that larger technology gap is related to more vertical spillover. Nevertheless, the empirical research trying to investigate this issue is rarely seen. Although several studies are aimed at quantifying the influence the technology gap might have on the spillover level[4], none of them take into the account the vertical interaction across industries. Le and Pomfret (2010) is the most similar to our study in the sense that they consider both vertical spillover and technology (measured by labor productivity) gap, but the result is inconclusive. Also, since the "technology gap" term enters the model separately from the spillover index, the assumption is that these two variables will have a linear correlation, while this might not always be correct (Perez, 1997).

In this study, we would like to relax the above assumption and take a different approach by studying how foreign investors with different TFP levels affect the spillover they might

[4]In the macro level, Baltabaev (2014) shows technology gap is positively associated with TFP growth whereas Lai et al. (2009) use Chinese provincial data to present a non-linear relationship between the technology gap and spillover level. As for micro-level evidence, Liu et al. (2000) use UK data to show that after controlling firms' own stock of indigenous knowledge (intangible assets per worker in locally-owned firms to those in foreign-owned firm), technology gap (value added per employee in a foreign firm/local firm in each industry) is found to be negatively correlated with the labor productivity of local firms in the same industry. In contrast, Blalock and Gertler (2009) apply Indonesian data and indicate that within the industry, the larger the technology gap, the more productivity gain local firms will receive.

induce to the Vietnamese suppliers located in the upstream industries. We will group foreign investors based on different thresholds of ex ante productivity level and see how each group promotes the local suppliers' TFP. The detailed methodology will be described in the next section.

4 Data and estimation strategy

4.1 Data

This paper uses a panel dataset constructed from the Vietnam Enterprise Survey at firm level. The Vietnam Enterprise Survey data is collected annually by the General Statistics Office (GSO) of Vietnam for all industrial sectors as of March 1st of each year. The general objectives of this survey are: (i) to collect the business information needed to compile national accounts; (ii) to gather up-to-date information on business registrations; and (iii) to develop a statistical database of enterprises. This panel dataset covers ten years, from 2002 to 2011, in which Vietnam experienced two major economic changes, namely WTO accession and the global economic crisis. The majority of the firms in the dataset can be found in the list of Vietnam Standard Industrial Classification (VSIC) codes[5], including all 22 manufacturing sectors out of 42 in total. Profiles of firms concerning ownership, labor, capital stock, turnover, assets, FDI, wage, materials inputs and other information are provided[6]. In our estimation model, we measure capital and labor by fixed asset and total labor at the end of year. Output and capital are deflated using annual GDP[7]. Above that, the GSO surveyed all multinational enterprises (MNEs), which are defined as firms that have foreign capital[8]. An advantage of this dataset is that the country that represents the ownership of the firm is

[5]We use the first 2-digits indicated in VSICcode2007 and VSICcode1993 to identify industries. For simplicity we aggregate some sectors. The details are available upon request.

[6]Census is taken for firms with more than 10 employees (over 20 employees in 2010 and 2011).

[7]Producer Price Index in the sector level is a preferred deflator but such data are not available for Vietnam.

[8]The sampling methods varied for private firms across years.

also reported[9]. Each firm is given a unique "enterprise code", and it is used together with the province code to identify firms and construct the panel dataset.

To achieve more accurate estimation results, we eliminate the missing observations and outliers. Firms in the top and bottom one percentile of all firm-specific output and input variables (in the means of annual growth) were deleted from the sample. Also the top and bottom 1% of output/capital and output/labor are excluded.

4.2 Estimating the firm productivity

TFP is the most commonly used measure of the effect of FDI spillover on a firm's performance in the literature (see, for example, Javorcik 2004). Although there are many ways to estimate TFP, we choose two alternative approaches that are suitable to our data situation, namely stochastic frontier estimation, and Levingsohn and Petrin's (2003) firm-level productivity estimation. The former has the advantage of isolating statistical noise from genuine productivity whereas the latter has the advantage of incorporating explicitly the correlation between unobservable productivity shocks and input levels.

Let us begin by using the traditional econometric approach to estimate TFP to illustrate the advantages of our approaches. The Cobb-Douglas production function is written as:

$$lnY_{it} = \alpha + \beta_k lnK_{it} + \beta_l lnL_{it} + \varepsilon_{it} \tag{1}$$

where Y_{it} stands for firm i's net revenue in year t. K and L represent capital and labor respectively, ε_{it} is the unobserved error term. Once this model is estimated using ordinary least squares (OLS), TFP is calculated by normalizing the exponential transformation of the residual[10]. The well-known drawback of this approach is its inability to isolate genuine productivity from statistical noise.

[9]We only count the foreign ownership with the largest share. For example, if Japan's share of investment is the largest, we consider the firm to be a Japanese-invested firm.

[10]The intercept is usually corrected make the estimated TFP to fall within the appropriate range.

The stochastic frontier analysis overcomes this drawback by including two error components representing both (the inverse) technical efficiency and statistical noise. According to Kumbhakar and Lovell (2000), the model is specified as:

$$lnY_{it} = \beta_0 + \sum \beta_n lnx_{ni} + v_i + u_i \tag{2}$$

where x_{ni} is a vector of inputs. v_i is the noise component and u_i is the nonnegative technical inefficiency component. Here, technical efficiency derived by inverting the technical inefficiency estimate is the measure of TFP. A half normal, exponential and Gamma distributions are often assumed on u_i to ensure non-negativity of productivity estimates whereas a full normal distribution is assumed on v_i as is common for random noise. The conditions for the error components for the normal-half normal model are: (i) $v_i \sim iid \quad N(0, {\sigma_v}^2)$ (ii) $u_i \sim iid \quad N^+(0, {\sigma_v}^2)$ (iii) v_i and u_i are distributed independently of each other, and of the regressors.

This model is estimated by maximum likelihood estimation. Once estimates of u_i are obtained from the residual of the model, the technical efficiency of the firm can be obtained by:

$$TE_i = exp\{-\hat{u}_i\} \tag{3}$$

where $\hat{u}_i$ is $E(u_i \mid \varepsilon_i)$ [11]. Alternative distributional assumptions on u_i can be accommodated simply by replacing (ii).

Meanwhile, the Levinsohn and Petrin (2003) method tries to alleviate the bias caused by correlation between unobservable productivity shocks and input levels. The detailed discussion can be found in Ni et al. (2015). When the method is applied, however, the lack of data on intermediate input, is a critical constraint for us. We do not have a direct measure of intermediate input, instead, we use " work-in-process " as a proxy variable for

[11] $E(u_i \mid \varepsilon_i) = \mu_i^* + \sigma^* \frac{\phi(-\mu_i^*/\sigma^*)}{1-\Phi(-\mu_i^*/\sigma^*)} = \sigma^*[\frac{\phi(\varepsilon_i\lambda/\sigma)}{1-\Phi(\varepsilon_i\lambda/\sigma)} - \frac{\varepsilon_i\lambda}{\sigma}]$, σ and λ are σ_u and λ_v ; ϕ and Φ are density and cumulative density functions respectively.

intermediate input. “Work-in-process” is an appropriate proxy because products that are uncompleted in the previous period are to be brought into the production line in the current period and to be completed. Also, it has to be noted that we interpolate input variables to avoid losing too many observations due to the use of the lagged inputs in the Levinsohn and Petrin model. These caveats are thought to reduce reliability of our estimation using this structural approach. Thus, we rather use this model as a supplementary tool for the stochastic frontier analysis.

4.3 Estimating the spillover effect

Now we proceed to the methodology to estimate the effect of FDI on the estimated TFP. A standard reduced form is used where a firm' s TFP is regressed on measures of the FDI spillover and other covariates, as in Javorcik and Spatareanu (2011). The FDI spillover variables are built based on the influence of FDI within the same industry and downstream industries. Since Ni et al. (2015) have shown that only investors from Asian regions tend to induce significant spillover effect, we will focus on Asian investors' impact while controlling for investors from other major areas[12]. The estimation model becomes:

$$\begin{aligned} lnTFP_{it} = Horizontal\_Group_{jt-1} + Vertical\_Group_{jt-1} + Herfindal_{jt-1} \\ +\alpha_i + X_{it} + \eta_t + u_{it} \end{aligned} \tag{4}$$

where the variable $Vertical\_Group$ is defined as:

$$Vertical\_Group_{jt} = \sum_{k \neq j} \alpha_{jkt} Horizontal\_Group_{kt} \tag{5}$$

$lnTFP_{it}$ is the logarithm of TFP of a local firm i, at time t. Following the formula

[12] Another advantage is that the geographical heterogeneity which might affect the spillover level can also be ignored. However, for the robustness check, we also conduct the analysis to include the factor of country of origin, and the results remain unchanged

developed by Javorcik and Spatareanu (2011), we define $Horizontal\_Group$ as the share of the output produced by foreign firms within sector k in year t, and α_{jkt} is the coefficient representing the proportion of sector j ' s output used by sector k in year t[13]. All the coefficients are taken from the Vietnamese Input-Output Table (IO Table) 2007. The "Group" term attached to each spillover variable depends on how we group foreign investors. Since we focus on how the productivity difference for Asian investors matters, we will choose different TFP threshold "φ" to divide Asian investors into subgroups. Thus the above equation can be rewritten as:

$$
\begin{aligned}
lnTFP_{it} = Horizontal\_Group_{jt-1} + \sum_{\varphi=1}^{P} Vertical\_Asia^{\varphi}_{jt-1} + Vertical\_Europe_{jt-1} \\
+ Vertical\_NorthAmerica_{jt-1} + Herfindal_{jt-1} + \alpha_i + X_{it} + \eta_t + u_{it} \qquad (6)
\end{aligned}
$$

where P stands for the number of thresholds we use. The potential spillover induced by European and North American investors are also included[14]. Since there might be a time lag for spillover to occur, we use the one-year lags of each variable as independent variables. X_{it} represents firm covariates. In particular, we need to control a local firm's own effort to absorb the technology, which is calculated as R&D expenditure/Net turnover. We also include the industry-level Herfindahl index. Firm fixed effect α_i and year dummy η_t are being controlled.

For the industry classification, we follow that of the IO Table 2007 because we need to explore the industry linkage to construct vertical spillover variables. However, because the Enterprise Survey follows VSICcode industry classification, we had to match the industries in the dataset with those used in the IO Table. In the end, our industry categories reduced from 138 to 42 (Half of them are manufacturing sectors). Furthermore, the VSICcode system changed from VSICcode1993 to VSICcode2007 in year 2007, and therefore, the industry codes

[13]When we calculate α_{jkt}, sector j ' s output sold for final consumption was excluded.

[14]Since investors from Asia, Europe and North America occupy more than 90% of the observations in the dataset, we ignore the influence of investors from other regions for the time being.

used in prior to 2007 are converted in accordance with VSICcode2007 by using a 1993-2007 concordance table[15].

4.4 Grouping the Asian investors

When it comes to the grouping of the Asian investors, we need to choose the TFP thresholds that might cause the structural change of the influence that the investors might have on the spillover level. In order to determine such thresholds, statistical tests have to be conducted and we adopt a modified Stepwise Chow Test[16]. The idea is that suppose we have a baseline estimation model:

$$y_t = \beta_0 + \beta_1 Vertical\_Asia + u_t \tag{7}$$

We want to verify that apart from the total vertical spillover, whether there is substantial change if we include an additional term which reflects the partial influence of Asian investors. We then run an augmented model:

$$y_t = \beta_0 + \beta_1 Vertical\_Asia + \beta_\varphi Vertical\_Asia^\varphi + u_t \tag{8}$$

where we use the sum of squared residuals from equations (8) and (7) to test the null hypothesis $H_0 : \beta_\varphi$. The F statistics are calculated as follows:

$$F = \frac{SSR_1 - SSR_2}{SSR_1} \cdot \frac{N-k}{q} \tag{9}$$

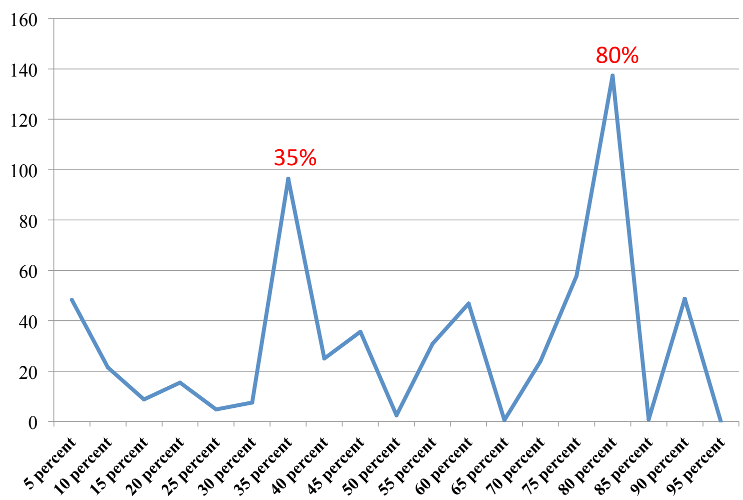
q is the number of restrictions and k is the number of parameters. We replace the term $Vertical\_Asia^\varphi$ each time we change the value of φ. In practice, we will use percentiles of the φ distribution among Asian investors and start from the lowest (i.e. from 1% cutoff to 100% cutoff). The purpose is to find out the largest F statistics and determine the

[15]The table is made based on the content description of the sector.

[16]We made reference to Lai et al. (2009).

correspondent φ. The result of the test is illustrated in Figure 2.

Figure 3: Chow F statistics by TFP percentage (Asian).



Source: Author's own calculation based on Vietnamese Enterprise Survey data.

As we can see, at the 80% cutoff there is a huge spike, which indicates the potential structural change starting from this value. At the 35% another spike is observed, but less steeper. Thus we first use 80% TFP cutoff as our main criteria, and divide Asian investors into ">80%" and "<80%" groups. Then we need to construct the vertical Asian spillover indexes based on the observations within each range respectively. In the next attempt, we will use the 35% cutoff to further divide "<80%" group into lower and middle subgroups. Both estimation results will be shown in the following section.

5 Estimation results

5.1 Results for using 80% TFP cutoff

The baseline estimation results using equation (6) are shown in Table 1. We observe negative signs for $Horizontal\_Group$ throughout the models, and this indicates the presence of a strong replacement effect by investors in the same industry. As for the variable of interest—vertical_Asia, only the one that is constructed using the "<80%" group of samples

Table 1: Baseline grouping (80% TFP cutoff)

	(1)	(2)	(3)	(4)
		Stochastic Frontier		
Dependent Variable	LnTFP	LnTFP	LnTFP	LnTFP
Horizontal_total (lag 1)	-0.0425***		-0.0136	
	(0.00804)		(0.00843)	
Vertical_Asia (lag 1) (>80%)	0.00937*	0.0127**	-0.00173	-0.00390
	(0.00477)	(0.00501)	(0.0183)	(0.0195)
Vertical_Asia (lag 1) (<80%)	0.0330***	0.0277***	0.0370***	0.0371***
	(0.00873)	(0.00819)	(0.00957)	(0.00991)
Vertical_Europe (lag1)	-0.149*	-0.116	-0.0123	-0.0283
	(0.0896)	(0.0876)	(0.104)	(0.106)
Vertical_NorthAme (lag1)	0.338	0.332	-0.151	-0.0426
	(0.338)	(0.337)	(0.321)	(0.339)
Own_effort	-8.09e-05	-0.000105	-7.37e-06**	-7.32e-06**
	(0.000142)	(0.000148)	(3.50e-06)	(3.59e-06)
Herfindal Index	0.224**	0.269***	-0.139	-0.0271
	(0.0912)	(0.0980)	(0.145)	(0.125)
Observations	421,438	420,810	421,535	420,908
R-squared	0.044	0.044	0.055	0.055
Horizontal_origin control	No	Yes	No	Yes
Time FE	Yes	Yes	Yes	Yes
Industry FE	No	No	Yes	Yes

Note: Standard errors in parentheses, clustered at industry level.

*** p<0.01, ** p<0.05, * p<0.1

Horizontal_origin includes Horizontal_EU, Horizontal_NorthAme, Horizontal_Asia (<80%) and Horizontal_Asia (>80%).

shows consistent and significant results. Also the coefficient is larger than that of the spillover index induced by the ">80%" group. This reveals that it is the Asian investors that are endowed with relatively lower TFP level, have the most spillover effect on their upstream Vietnamese suppliers.

5.2 Result for using both 35% and 80% TFP cutoffs

When we decompose the "<80%" group by adding the 35% TFP cutoff, the result is even more explicit. As can be seen in Table 2, among the three groups, i.e. low, middle and high-TFP Asian investors, only the ones within middle TFP range (35%-80%) induce the most positive and significant vertical spillover. In the meantime, Asian investors within low TFP range (<35%) have a negative impact on Vietnamese suppliers' TFP. The explanation for this is that since Asian investors that have the most similar technology as local firms do are likely to purchase the same parts that local firms will also use. Under certain circumstance, it is difficult for the spillover to occur, and on the contrary, these Asian investors will pose as a "threat" to their local suppliers and thus suppress the TFP growth of the latter.

5.3 Robustness checks

Several issues are worth extra care to confirm the robustness of our findings. One might argue that the difference of spillover impact is due to geographical heterogeneity. For instance, Vietnam has close business connection with Japan and China, and such special bond will enhance the interaction between investors from these countries and local suppliers. But it is not the case for investors from other Asian regions. If the distribution of Asian investors within 35%-80% range is not random, then it will contaminate our estimation of technology gap's sole influence on the vertical spillover.

To alleviate this concern, we give the list of Asian investors in the "middle" subgroup. As shown in Table 4, investors with middle-level TFP are not limited to a particular country, rather, they are scattered, ranging from East Asia to South Asia. This gives us the reason

Table 2: Baseline grouping (35% and 80% TFP cutoffs)

	(1)	(2)	(3)	(4)
		Stochastic	Frontier	
Dependent Variable	LnTFP	LnTFP	LnTFP	LnTFP
Horizontal_total (lag 1)	-0.0445***		-0.0104	
	(0.00832)		(0.00767)	
Vertical_Asia (lag 1) (<35%)	-0.375**	-0.486***	-0.373**	-0.386**
	(0.145)	(0.149)	(0.150)	(0.152)
Vertical_Asia (lag 1) (35~80%)	0.0486***	0.0471***	0.0278**	0.0276**
	(0.0139)	(0.0135)	(0.0118)	(0.0119)
Vertical_Asia (lag 1) (>80%)	0.00528	0.00886*	-0.0111	-0.0123
	(0.00501)	(0.00534)	(0.0190)	(0.0194)
Vertical_Europe (lag1)	-0.160*	-0.115	0.0109	0.00443
	(0.0881)	(0.0849)	(0.103)	(0.100)
Vertical_NorthAme (lag1)	0.567*	0.525	0.0913	0.101
	(0.330)	(0.325)	(0.325)	(0.333)
Own_effort	-3.69e-05***	-3.71e-05***	5.78e-06	5.56e-06
	(5.91e-06)	(6.11e-06)	(6.36e-06)	(6.30e-06)
Herfindal Index	-0.176***	-0.0975*	-0.0208	-0.0156
	(0.0573)	(0.0553)	(0.0576)	(0.0721)
Observations	421,450	420,822	421,428	420,801
R-squared	0.043	0.044	0.054	0.054
Horizontal_origin control	No	Yes	No	Yes
Time FE	Yes	Yes	Yes	Yes
Industry FE	No	No	Yes	Yes

Note: Standard errors in parentheses, clustered at industry level.

*** p<0.01, ** p<0.05, * p<0.1

Horizontal_origin includes Horizontal_EU, Horizontal_NorthAme, Horizontal_Asia (<35%), Horizontal_Asia (35%~80%) and Horizontal_Asia (>80%).

to believe that geographical (or cultural) difference might not be as serious as we have considered, though further effort is needed to justify this point.

Another issue is that the ownership of the foreign investors can affect the spillover they induce to domestic firms, since joint ventures may face lower costs of finding local suppliers of intermediates and thus be more likely to engage in local sourcing than wholly owned foreign subsidiaries (Javorcik and Spatareanu, 2008). We thus generate the new vertical spillover indexes based on the foreign investor's ownership (fully or partially owned) and include them in equation (6). The estimation results remain unchanged[17].

Also there might be concern on the measurement error of the TFP cutoffs. To confirm this, we use 25% or 50% TFP cutoff to replace 35% when dividing the <80% group. We still come up with the same result regardless of which cutoff value we use. It is the Asian investors with middle-level TFP that induce the most significant vertical spillover to their Vietnamese suppliers.

To sum up, we can find a nonlinear correlation between the technology level that Asian investors own and the vertical spillover they might have on the local suppliers, which can be depicted in Figure 4. The horizontal axis indicates the average TFP level of Asian investors (or shown as percentile) and the vertical axis reveals the induced vertical spillover. The vertical spillover keeps increasing but insignificant until φ reaches point a. Before φ reaches b the vertical spillover will be significant or even be maximized in some point above the line "L". Taking into account the fact that most Asian investors have a higher average TFP level than Vietnamese suppliers do, we can describe the relationship between the technology gap (for Asian investors and Vietnamese suppliers) and the vertical spillover as an inverted-U shape.

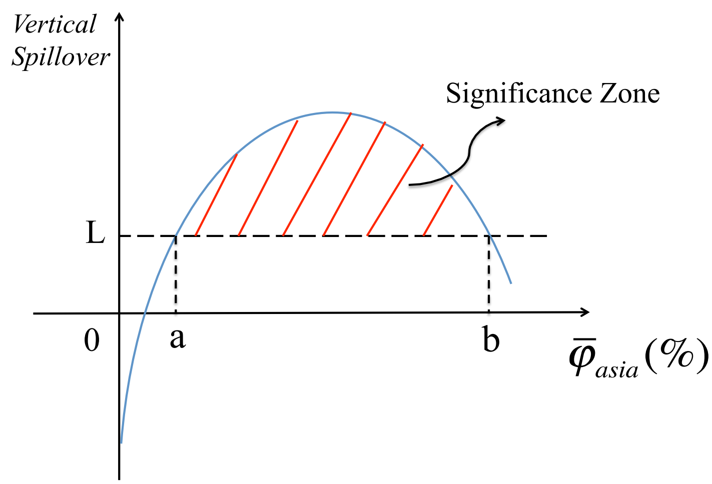
[17]We do not include the results due to space constraint, but they are available upon request.

Table 3: List of Asian investors (between 35% and 80% TFP cutoff)

Countryname	Countrycode	Number of firms	Percent (%)
Taiwan	1320	5,306	34.33
Korea, Republic	1311	3,106	20.1
Japan	1307	2,906	18.8
Singapore	1108	1,218	7.88
China	1304	1,009	6.53
Hongkong	1305	647	4.19
Malaysia	1105	591	3.82
Thailand	1109	384	2.48
Philippine	1107	90	0.58
Indonesia	1103	47	0.3
India	1306	41	0.27
Brunei	1101	22	0.14
Israel	1204	21	0.14
Bangladesh	1302	14	0.09
Sri Lanka	1318	13	0.08
	Total	15,415	

Source: General Statistics Office, Vietnam.

Figure 4: Concept of implication.



6 Conclusions

By far the spillover impact of FDI has been widely investigated. In this paper, we examine how productivity gap and vertical spillover are correlated in the context of Vietnam. In particular, we focus on Asian investors, which are most likely to induce vertical spillover to local suppliers, as shown in the previous literature. After applying statistical method to divide Asian investors by different TFP cutoffs, we show that the relationship between the productivity gap and vertical spillover takes an inverted-U shape, i.e. Vietnamese suppliers can achieve the most TFP gains from the diffusion of the Asian investors with middle-level TFP.

The empirical results are robust against several sensitivity checks, thus providing the evidence that not all the foreign investors with the most advanced technology can bring about the benefits to the local economy. In some scenario, high-tech foreign investors might want to protect their "core" competence and only outsource the minor components to the local processing firms or suppliers. If that is the case, Vietnamese government should foster Vietnamese firms to improve their technology level and adopt new policies to promote the corporation between foreign investors and local firms.

7 Appendix

Table A1: TFP comparison among different methods

TFP scores	N	mean	sd	max	min
OLS	513913	0.001	0.004	1	0
SF	513913	0.513	0.165	0.81	0.008
LP	513913	0.028	0.046	1	0

Source: Author's own calculation based on Enterprise Survey, GSO, Vietnam

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