VERTICAL AND HORIZONTAL FDI TECHNOLOGY SPILLOVERS IN THAI MANUFACTURING: DOES MEASUREMENT MATTER?

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ABSTRACT

While earlier studies emphasize the role of vertical FDI spillovers, their empirical models have two main shortcomings. First, they employ the measures capturing only direct industrial linkages. Second, their models are under an implicit assumption that vertical spillover automatically takes place after the indigenous firms are linked with MNEs. This study aims to examine whether these shortcomings distort the empirical findings of FDI spillovers, using the firm-level data from Thailand in the year 2011. When the implicit assumption is relaxed, the empirical finding points out that measuring only direct linkages underestimates the actual roles of linkage effects, which leads to overemphasis on vertical spillovers. The evidence of heterogenous FDI spillovers is also found, i.e. the trade policy regime as conditional gains of FDI spillovers. The key policy implication is that liberalizing the trade policy should go hand in hand with contemplating both direct and indirect linkages, in order to maximize gains through FDI technology spillovers.

Keywords: FDI Technology Spillover, Trade Policy, Thailand.
JEL Classification: F14, O24, D24.

I. INTRODUCTION

The presence of Foreign Direct Investment (FDI) could generate several impacts to the host country, which can be generally categorized into the direct and indirect impacts. Nowadays, the additional capital fund provided by FDI inflow, which is often referred to the direct impact, is becoming less important. This is due to the integrated international capital market and the possibilities to borrow in the host country's capital market (Kohpaiboon, 2006a). Under this circumstance, the existing literatures have rotated to emphasize the roles of indirect ones. In particular, the indirect impact is technological gains resulting in the improvements of productivity and competitiveness of domestic industries through the presence of FDI, known as FDI technology spillovers. Therefore, several developing countries compete to attract FDI (see Harding & Javorcik, 2011). Nonetheless, only some countries have experienced the gains through FDI spillovers, empirically found.

While there are numerous channels, in which the presence of foreign affiliates could affect the productivity of indigenous firms, earlier studies give priority to the role of linkage effects. In many cases, it is referred to vertical spillovers, i.e. inter-industries spillovers. A number of studies have argued that it is more likely that FDI spillovers would take place through inter-industries spillovers as opposed to intra-industry ones, which is often referred to horizontal spillovers. This is because foreign affiliates may have an incentive to prevent their knowledge leakage, which would enhance the performance of their local competitors. In contrast, meanwhile, MNEs may benefit from transferring knowledge to their local suppliers, i.e. the backward linkage effect (Javorcik, 2004). On the other hand, the local firms could also more productive from using intermediate output, produced by multinational suppliers, as their input, i.e. forward linkage effect..

While several empirical evidences support the existing of vertical spillover as shown in Table 2.1, there are two main shortcomings. First, the consensus has not been reached that how the linkage should be measured. All studies with the exception of Kohpaiboon & Jongwanich (2013), focus on the direct linkages, i.e. employ measures used in Javorcik (2004). Most studies, employing such measures, usually found the empirical evidences of inter-industries FDI spillovers.

Nonetheless, an evidence of vertical spillovers are not found in Kohpaiboon & Jongwanich (2013), which employs the measures capturing both direct and indirect (inter-sectoral) repercussion. Moreover, there is no prior theoretical support why vertical spillovers are transmitted only through the direct linkage. Hence, it is worth to systematically examine whether the measure of linkages is sensitive to the presence of vertical spillovers.

TABLE I
SUMMARY OF EMPIRICAL STUDIES EXAMINING BOTH HORIZONTAL AND VERTICAL SPILLOVERS

Empirical literature	Country	Study period	Measures of Linkages	Horizontal	Vertical
Javorcik (2004)	Lithuania	1996-2000	D	0	B+,F0
Bwalya (2006)	Zambia	1993-1995	D	0	B+,F-none
Javorcik & Spatareanu (2008)	Romania	1998-2000	D	0	B+,F-none
Kugler (2006)	Colombia	1974-1998	D	0	B+,F0
Blalock & Gertler (2008)	Indonesia	1988&1996	D	0	B+,F-none
Marcin (2008)	Poland	1996-2003	D	+	B+,F0
Lin et al. (2009)	China	1998&2005	D	0	B+,F+
Managi & Bwalya (2010)	Kenya	1993-1995	D	+	B+,F-none
Barrios (2011)	Ireland	1983-1998	D	0	B+,F-none
Du et al. (2012)	China	1998-2007	D	0	B+,F+
Xu & Sheng (2012)	China	2000-2003	D	+	B+,F+
Kohpaiboon & Jongwanich (2013)	Thailand	2001-2003	D&IND	0	B0,F0

Source: The author's compilation.

Note: D denotes the measures capturing direct linkages, D&IND denotes measures capturing both direct and indirect linkages. 0 denotes insignificance, + denotes positive significance. B+ and B0 denote positive significance and insignificance on backward linkage, respectively. F+, F0 and F-none denote positive significance, insignificance and not examine on forward linkage, respectively.

Second, most studies are under an implicit assumption, that is, vertical spillover automatically takes place, after indigenous firms are linked with MNEs. One of exceptions[1] is Kohpaiboon & Jongwanich (2013), which argues that FDI spillovers are determined by the nature of trade policy regime. Interestingly, when such assumption is relaxed, neither backward nor forward linkage is found. In contrast, inter-industries spillovers turn out to be statistically significance, when imposing the assumption of identical FDI spillovers, i.e. omitting the determinant of FDI spillovers. The results may indicate that omitting determinant of FDI spillovers could result in biased estimate of vertical spillovers. Hence, the role of determinants of FDI spillovers are also needed to be systematically examined in this study, i.e. whether the existence of determinants distorts the empirical finding of the presence of FDI spillovers.

In this study, trade policy regime and absorptive capability are examined as the conditional gain of FDI spillovers. While both determinants of FDI spillovers are acknowledged, most studies usually examine only the role of the latter. This may due to a difficulty of finding a reliable proxy for the protection across industries (Kohpaiboon & Jongwanich, 2013). In particular, the role of trade policy regimes is referred to Bhagwati hypothesis which suspected that the gains through FDI spillover, under restrict trade policy regime (i.e. IS regime), are far less or even negative, comparing to industry under liberal trade regime (i.e. EP regime). Hence, the more the liberalized trade policy, the more the technological gains through FDI spillovers.

On the other hand, an absorptive capability of local firm is indicated by the technology gap between foreign affiliates and local firm. In other word, the absorptive capacity hypothesis is that FDI spillovers depend on the technological distance between foreign affiliates and local firms. In particular, when the gap is large, local firms might have relatively lower capacity to benefit through presences of foreign affiliates. By contrast, when the gap is small, it is likely that the foreign affiliates would transmit fewer technology gains to the local firms. Therefore, the

[1] See Görg & Greenaway (2004); Kohpaiboon (2006b); Crespo & Fontoura (2007); Hayakawa et al. (2008); and Kohpaiboon & Jongwanich (2013).

proper technology gap is the best state for gaining benefit through advanced technology associated with MNEs Against this backdrop, this paper aims to examine the presence of FDI technology spillovers in Thai manufacturing. The econometric analysis of cross-sectional data is conducted, using the Industrial Census gathered by the National Statistical Office of Thailand (NSO), Ministry of Information and Communication Technology, in the year 2012. This is the most up to date and reliable plant survey so far. In the empirical model, this study following the standard practice in this research area, in which the productivity equation of locally owned plants in the manufacturing sector is estimated. And the statistical relationship between local firms' productivity and the extent of foreign presence is examined. The expected contribution to existing literatures is that this study could shed light on how the industrial linkages should be measured. To do that, both measures of the linkages will be systematically examined, which has not been done by earlier studies.

According to Kohpaiboon & Jongwanich (2013), Thai manufacturing is a good laboratory for the issue in hand for two reasons. First, Thailand has been a large FDI recipient throughout the past decades, as well as FDI inflows in Thai manufacturing have been dispersed across import substitution and export promotion industries. Second, Thai manufacturing is broad-based as opposed to neighboring countries, covering a wide range of industries from traditional labor-intensive industries like garment and footwear to several key industries in the machinery and transport equipment sector such as automotive, electronics, and electrical appliances. Hence, evidence drawn from Thai manufacturing could provide an insightful lesson for other countries.

The paper is organized as follows: Chapter 2 provides an analytical framework illustrating updated knowledge relating to FDI spillovers. In the next chapter, the foreign direct investment in Thailand is discussed. The empirical analysis is provided in the fourth chapter. The final chapter is the conclusion and policy inference.

II. ANALYTICAL FRAMEWORK

This chapter aims to compile and discuss the most up-to-date knowledge of FDI technology spillovers derived through various relevant literatures. There are four sections, particularly the first section explains the overview of FDI technology spillover. In a next section, the channels in which foreign technology could transmit to local firms are reviewed. The debates on the characteristics and importance of horizontal and vertical spillovers are considered in the third section. The last section in this chapter provides the discussion focusing on the determinants conditioning technological gain through horizontal spillover.

A. The Impacts of FDI Inflows and FDI Technology Spillovers

Foreign direct investment (FDI) is often referred to the investment made to acquire a lasting interest in, or significant degree of influence on the management of the enterprise operating outside of the nation of the investor. In other words, FDI is regarded as the existence of long-term relationship between the direct investor and the invested enterprise, according to definitions of IMF and OECD. FDI inflows eventually have the potential to generate numerous impacts to the host country, which can be generally categorized into the direct and indirect impacts. In particular, involvements of FDI often provide additional capital funds, which lead to the reduction of capital cost as well as the expansion of domestic production. This is widely regarded as the direct impacts (Sjoholm, 1997; and Blomstrom et al., 2000). Nonetheless, the direct impact of FDI is becoming less important to some host countries, as a results of the integrated international capital markets and the possibilities to borrow in the host country's capital market (Kohpaiboon, 2006a). Instead, the emphasis is placed on the indirect impact, resulting in the local firms' productivity or efficiency improvements through the presence of foreign affiliates, i.e. FDI technology spillovers (Blomstrom & Kokko, 1998). In many cases, it is often argued that technology spillovers are the most desirable benefit through presences of MNEs.

Regarding how FDI spillovers taking place, this study follows the theoretical model developed by Wang & Blomstrom (1992). The model assumes that there are two firms, namely the foreign affiliate and the indigenous firm, producing differentiated but substitutable products for the local market. And, the entry of the foreign firm is typically associated with some amount of proprietary technology from the parent company, so as to offset a potential disadvantage against the local firm. In particular, the local firm might have possessed relatively superior knowledge of the availability of factor inputs, business practices and/or consumer preferences in their markets. So that, bringing advanced technology would help the foreign firm for competing in the local market.

Under this circumstance, the local firm can observe, learn, and adapt superior technology associated with the foreign firm to enhance its own technological capability. This is because the technology accompanied with the foreign firm has certain public good qualities, which cannot be fully internalized.

Since the market success of each firm depends on the level of technology, it encourages the local firm to learn the associated superior technology. Thus, the localization of the foreign firm could potentially generate positive externality in terms of technological benefit to the local firm.

Nonetheless, transferring technology from MNE's headquarter to its affiliates is costly. The more the advance of technology transferred, the larger the financial costs associated with the transfer. As a result, the foreign firm has to decide its effort to undertake transferred technology, in order to maximize its benefit. Indeed, the effort is determined by the local firm's response against the presence of the foreign firm. If the local firm actively puts in the effort to learn the advanced technology associated with the foreign firm, the technology superiority of the latter will not last long. Under this circumstance, the foreign one will need to keep undertaking technology transfer activities in the following period for maintaining the advantage or even surviving in the competitive environment. In contrast, if the local firm is less responsive in attempting to learn the associated technology, the foreign firm would have less incentive to continue to undertake technology transfers from its parent company. On the other hand, the local firm's effort, in learning and adapting the associated technology, is also associated with the amount of cost. So that the local firm also has to decide its effort to learn associated advanced technology. Similarly, the learning effort of the local firm also depends on the foreign firm's behavior. Hence, the gains through FDI spillovers depend on the interaction between foreign affiliates and local firms.

Furthermore, Sawada (2010) further develops a model of duopoly competition between a foreign affiliate and an indigenous firm, focusing on developing host-country. In particular, while the local firm may have incentive to gain the benefit through FDI spillovers, the multinational one may have incentive to prevent such circumstance enhancing its local competitor. The model further assume that the initiatives to gain and prevent technology spillover are costly as the previous model. Nonetheless, in this model, the role of both firms' marginal cost is crucial, particularly, the foreign firm is assumed to have lower marginal cost than the local one, due to its superior technology. So that, FDI spillovers arise when the indigenous firm has internalized the foreign knowledge, resulting in lower marginal cost. In consequent, the technology spillovers are defined as the marginal cost reduction of the local firm.

B. The Channels of FDI Technology Spillovers

Indigenous firms could be improved by the presence of foreign affiliates, while there are various channels in which the foreign technology could spill over to local enterprises. So that, understanding particular channels is extremely important because a characteristic of each channel is different. The thorough knowledge is needed to be acquired in order to be able to maximize benefit through FDI spillovers, accordingly. In consequent, as identified by FDI spillovers studies, there are at least three channels in which FDI spillovers have taken place, namely Demonstration effects, Labor mobility and Linkage effects.

B.1 Demonstration Effects

The presence of MNE induces demonstration effects, which allow local firms to become familiar with superior technologies, marketing and managerial practices used in foreign affiliates. Local firms might not know about certain technologies and advanced knowledge, until they become available in the domestic economy (Kohpaiboon, 2006a). For instance, once new technology is introduced into a domestic market, adopting that technology may be too expensive and risky for a local firm to undertake. Nonetheless, when the technology has been successfully used by foreign firm, the local firm will be encouraged to imitate particular technology, which would improve their productivity (Crespo & Fontoura, 2004). However, foreign investors have significant incentives to avoid any leakage of knowledge to their local competitors. Under this circumstance, a magnitude of technological benefit, in which local firms gain, depends on effectiveness of MNCs to protect their knowledge, the degree of product sophisticate, and ability of local firms to incorporate the potential knowledge into their production and management process (Pfeiffer et al., 2014).

On the other hand, the presence of foreign affiliates can exert pressure on local firms. The competition in the domestic market generated by foreign affiliates is an incentive for indigenous firms to enhance their technical, or allocation inefficiencies. This is because it allows local firm to be able to compete with foreign firms, or even successfully survive. For example, local firms may respond to the presence of foreign affiliates, in the short term, by improving their X-efficiency, such as enforcing more cost-conscious management as well as motivating employees to work harder.

Then, in the longer term, local firms would seek new technology or innovations, which allow them to sustainably upgrade their existing production (Kohpaiboon, 2006a). In contrast, the efficiency of the local firms might be harmed by the higher competition generated by foreign affiliates. In other words, the presence of foreign affiliates may lead to contraction of local firms by stealing their markets, resulting in a decrease in their productivity (Kim, 2014). More precisely, as pointed by Atiken and Harrison (1999), the negative relationship between the foreign presence and the productivity of domestic firms may be found in the short and medium runs. However, in the long run, the weakest local ones have to leave from the market, thereby it may reverses the sign of the relationship. In sum, the net effect of competition depends on the ability of local firms to compete with MNCs and the effectiveness of foreign affiliates to consolidate their market share (Kosava, 2010). Importantly, both demonstration and competition effects are likely to occur simultaneously. Hence, these two effects are often regarded, in the empirical literatures, as a single channel of spillover, accordingly.

B.2 Labor Mobility

MNEs often play more active role than local firms, in training and educating their local labor (e.g. Lindsey, 1986; Djankov & Hoekman, 2000; and Sousa, 2001). Foreign firms usually train the local labors in the most levels of employees, from manufacturing operative to technical advanced professional and top-level manager. Type of training range from simple training to seminar and more formal schooling to overseas education, depending on skill needed. For instance, based on the evidence of Czech Republic, the foreign affiliates spent 4.6 times more than local firms on training their employees (Filer et al., 1995). The various skills gained while working in foreign firm may spill over, either when the labors are recruited by local firms, or found their own business, and use their knowledge gained from their previous employment in foreign affiliate (Blomstrom & Kokko, 1998). Nonetheless, the foreign affiliates often offer their local labors the wage premium, in order to prevent the worker turnover, which could gain their local competitors (Javorcik, 2013). On the other hand, a labor mobility does not necessarily generate only positive impact towards local firms. In fact, a presence of foreign affiliates could also negatively affect local firms by recruiting their talents (Blalock & Gertler, 2008).

B.3 Linkage Effects

Indigenous firms could be more productive through contracts with their multinational customers and suppliers. The former is referred to a backward linkage, while the latter is regarded as a forward linkage. The backward linkage effects are created when local firms become suppliers for multinational firms. In general, foreign affiliate often demand for better and/or more diverse immediate outputs, i.e. demand effect (Winkler, 2013). Under this circumstance, local firms need to enhance their productivity and efficiency, while enjoying return to scale. Meanwhile, MNEs might have to directly assist local suppliers to enhance their technological capability, i.e. assistance effect (Paus & Gallagher, 2008). For example, foreign customers might share their production techniques, product design and technology acquisition. Moreover, MNEs might offer a personal training, an advance payment, a leasing of machinery provision of inputs and/or a quality assurance, or even share an organization of product lines (Javorcik & Spatareanu, 2008). While the demand and assistance effects are intentionally provided by multinational ones, unintentional FDI spillovers through backward linkages could also exist. In particular, such scenario could take place through technology leakages to other supplying firms in a same sector, i.e. diffusion effect (Winkler, 2013).

On the other hand, the forward linkage effects could exist, when local firms use intermediate outputs produced by foreign firms in upstream industry as their inputs. Local firms may become more productive through gaining access to new, reliable, higher quality and/or less costly intermediate products, i.e. availability and quality effects (Javorcik & Spatareanu, 2008). In consequence, the total linkage effect is the sum of backward and forward linkages, which can be seen as the growth in other industries induced by establishing MNE affiliates (Kohpaiboon & Jongwanich, 2013).

C. Horizontal Spillovers versus Vertical Spillover

The existing literature often examine FDI spillovers in form of horizontal and vertical spillovers, instead of the channels discussed above. This sub-section is conducted to acknowledge the definitions of horizontal and vertical spillovers in this study. On the one hand, horizontal spillovers often refer to intra-industry spillovers, including both demonstration effect and labor mobility within an industry.
However, the data relating working experiences of owners and labors in local firms is not available, thereby only demonstration effect within industry is eventually regarded as horizontal spillover, in this study. On the other hand, FDI spillovers across industries are often regarded as vertical spillovers. So that, inter-industry demonstration effect and labor mobility, as well as linkage effect are captured in this context. Inter-industries labor mobility are unable to be examined as mentioned above. Meanwhile, inter-industry demonstration effect is complicated to compute in practice. Under this circumstance, vertical spillovers in this study is examined only by the linkage effects. Hence, this study examines horizontal and vertical spillovers by investigating the intra-industry demonstration effect and the linkage effects, respectively.

D. Determinants Factors of Horizontal Spillovers

As discussed in the first chapter, several studies implicitly assume that FDI spillovers are identical for all industries, i.e. ignoring the determinants of FDI spillovers. This assumption seems to contradict a number of studies[2] pointing out the heterogeneity of FDI spillovers. In other words, economic analysis under this assumption could result in biased estimates, as a result of omitting variable problem. Furthermore, according to Irsova & Havranek (2013), they collect more than thousand estimates of horizontal spillovers in their meta-analysis and found that intra-industry ones are on average zero, whereas their sign and magnitude depend on the heterogeneity in host country. Hence, this implies that heterogeneity of FDI spillovers is much needed to be recognized so as to gain the technological benefit, especially through horizontal ones. To do that, several literatures try to clarify what kinds of heterogeneity in either foreign affiliates, indigenous firms or host-country policies are crucial. In consequence, there are at least two factors have been identified, i.e. absorptive capability and trade policy regime.

D.1 Absorptive Capability

An absorptive capability is often referred to technological gap between foreign affiliates and local firm (Kokko, 1994; Blomstrom & Sjoholm, 1999; and Sjoholm, 1999). In an early theoretical paper, the speed of adoption of new technologies, i.e. FDI spillovers depend on the technological distance between host and home countries of foreign affiliates. Initially, researchers argue that the wider the technology gap, the higher the potential for positive spillovers (Findlay, 1978). After that, the view on technology gap has considerably changed, the literatures still focus on the role of technological distance, whereas they perceive the technology gap as indicator of the absorptive capability of the local firms. That is, the ability to internalize knowledge created by the others and modify such knowledge to fit their own specific application, processes and routine (Narula & Marcin, 2003).

The relationship between technology gap and FDI spillover is theoretically non-linear. On the one hand, the larger the gap, the lower the human capital and the technological know-how to benefit through presences of foreign affiliates, the lower the potential for spillovers benefit (Girma & Gorg, 2005). This is because local firms with large gap are far behind best practice and could lack of the technical competency needed to catch up. The magnitude of FDI spillovers will increase with the smaller technological gap, as it increases the opportunities of efficiency via imitation of foreign technology (Crespo & Fontoura, 2007). On the other hand, when the technological gap is small, the foreign affiliates will transmit few technology gains to the local firms (Kokko, 1994). This is because firms with smaller gap often lack the incentive to alter existing practices. Moreover, these firm may have already invested in low-hanging fruit technologies, which are low cost and high return, thereby it is more complicated to further improve their capacity (Blalock & Gertler, 2009). Therefore, it is maintained that local firms should have a moderate technological gap vis-à-vis foreign affiliates in order to maximize the gains through the advanced technology associated with MNEs.

[2] For example, see Görg & Greenaway (2004); Kohpaiboon (2006b); Crespo & Fontoura (2007); Hayakawa et al. (2008); and Kohpaiboon & Jongwanich (2013).

A number of the studies[3] perceive quality of the human capital as firms' absorptive capability. In particular, the human capital might influence local firms' adoption of multinational technology. This is because indigenous firms need the abilities to recognize, assimilate and apply new technology in order to exploit external knowledge through MNEs (Girma & Wakeline, 2007). When local firms have observed new technology, therefore, they need savvy employees with sufficient training and educational background allowing them to adopt such knowledge.

D.2 Trade Policy Regime

The impact of trade policy regime on FDI technology spillovers was pioneered by Bhagwati (1978)[4]. In particular, he hypothesized that gains through FDI are far less or even negative, under restrict trade regime (i.e. IS regime), than under liberal trade regime (i.e. EP regime). This conditional gain is often referred to Bhagwati hypothesis. In consequence, FDI under restrict trade regime usually flow to an industry with high trade restrictions, in order to supplies their output in a highly protected domestic market. Under this circumstance, although the foreign affiliate's production technology are less advanced than such technology used in its home country, it is often relatively capital- and skill-intensive compared to the local firm's technology. So that, it is more complicated for local firm to learn the advanced technology. In some case, the local firms may have incentive to avoid competition by establishing production in other industry, and take benefit of economic rents induced by the regime. Thus, in this situation, it is less likely that foreign technology will spill over to local firms.

In contrast, under liberal trade regime, FDI inflows are attracted to industries in which the host country has comparative advantage, e.g. relatively lower labor cost or availability of raw materials. Meanwhile, the local firm, in those industries, often have greater potential to catch up with foreign firm, and achieve productivity improvement. Hence, it is more likely that liberal trade policy will generate more FDI spillover from FDI involvement to local firm.[5] Nonetheless, Nobakht & Madani (2014) indicate a negative effect of the trade liberalization on stimulating the FDI spillovers, particularly they employ trade policy liberalization as absorptive capacity factor on the FDI-led growth nexus, using data from 33 middle-income countries over 1990-2011.

III. Foreign Direct Investment in Thailand

A. Foreign Direct Investment and Trade Policy in Thailand

This Section aims to illustrate the relationship between the foreign presence and trade policy across industries, disaggregated into 4 digit ISIC classification in the Thai manufacturing sector. The calculated foreign presence (*FOR*) is plotted together with the proxy for trade policy, in order to reveal whether the trade policy determines the foreign affiliates in locating in particular industries. *FOR* here is measured from output shares of foreign affiliates (i.e. firms with foreign shares exceed 10 per cent). The trade policy is proxied by the effective rate of protection (*ERP*). The output and foreign shares are based on the industrial census in the year 2012, while *ERP* is obtained from Jongwanich & Kohpaiboon (2007). In addition, since the number of industries is not high, the analysis might be distorted by outliers. Under this circumstance, the Cook's distance is employed for identifying outlier, which is further deleted from consideration. [6]

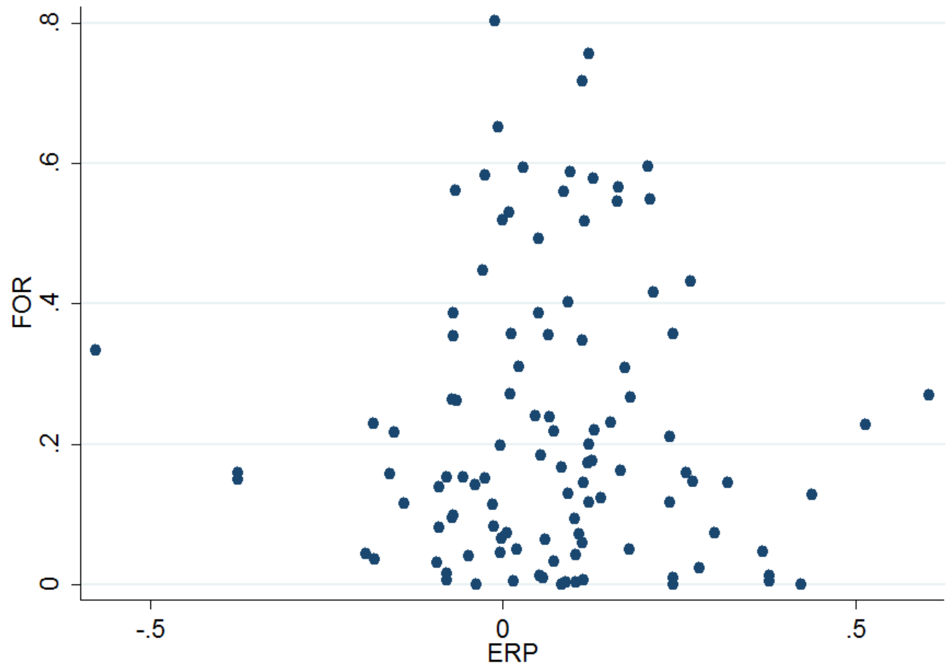
The average *FOR*, from 111 industries, is 22.09 per cent with the maximum of 90.16 percent in repair and maintenance of machines, computers and computer peripheral devices (ISIC7250), and minimum of 0 per cent in malt liquors and malt (ISIC1553), publishing of books and other publications (ISIC2211), other publishing (ISIC2219), reproduction of recorded media (ISIC2230), cutting, shaping and fishing of stone (ISIC2296) and other transport equipment (ISIC3599). On the other hand, *ERP* is averaged out at 0.02 with the maximum of nearly 0.61 in structural and metal product (ISIC2811) and minimum of -0.57 in tanning and dressing of leather (ISIC1911).

The scatter plot, in figure 1, indicates insignificantly negative relationship between foreign presence and trade policy. The spearman correlation is -0.03 without statistical significance. Hence, there is no clear relationship between *FOR* and *ERP* in Thai manufacturing through both the statistical and econometric analyses. In the other words, this finding points out that trade policy may no longer determine the foreign presence, which is different from recent structure in Thai manufacturing. For example, in the late 1970s, FDI was predominantly in import-substitution industries (i.e. high trade protection regime), such as textiles, automobiles and chemicals. After that,

[3] For example, see Sinani & Meyer (2004), Girma & Wakelin (2007), Blalock & Gertler (2009) and Kohpaiboon & Jongwanich (2013)
[4] And were further developed by Bhagwati (1985, 1994); Brecher & Diaz-Alejandro (1977); and Breecher and Findlay (1983).
[5] For more details, see Kokko et al., 2001; Kohpaiboon 2006b; and Kohpaiboon & Jongwanich, 2013
[6] The indicator of foreign presence, employed data and Cook's distance are fully discussed in the next chapter.

FDI started rotating to industries under export-oriented policy (i.e. liberal trade regime), such as clothing, footwear and toys.

FIGURE I



CORRELATION BETWEEN FOREIGN PRESENCE (*FOR*) AND EFFECTIVE RATE OF PROTECTION (*ERP*)

Note: The statistical correlation between *FOR* and *ERP* is not different from zero, based on the simple ordinary least square estimation in which *FOR* and *ERP* are dependent variable and independent variable, respectively.

$$FOR = 0.22 - 0.05ERP$$

(10.69)*** (-0.41)

(t-stat in parenthesis)

Source: Author's compilation. See full data in Appendix.

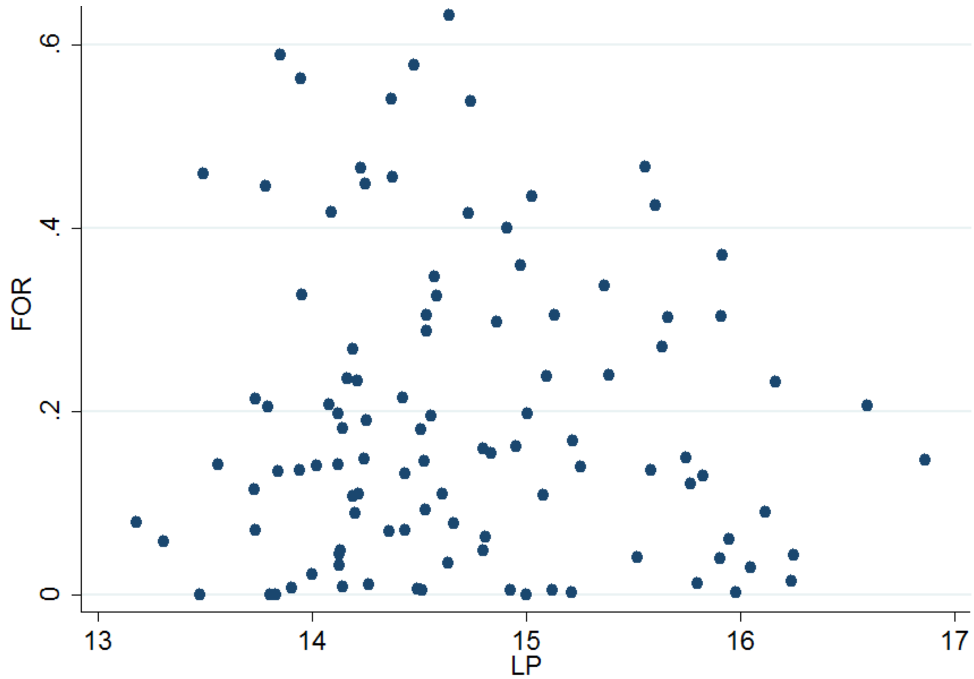
B. Foreign Direct Investment and Labor Productivity

This section aims to re-examine the preposition that FDI inflows in Southeast Asia, including Thailand, predominantly belong to the efficiency-seeking and/or export-oriented categories (Hill & Athukorala, 1998). The former is studied by illustrating the relationship between foreign presence and industry's labor productivity, where the latter is investigated in the next section. The foreign presence (*FOR*) is measured by the approach used in the previous section. Industry labor productivity (*LP*) is measured from sum of firm's value added per workers (*VA/L*) weighted by each firm value added (*VA*), where *VA* is defined as the difference between gross output and raw materials net of changes in inventories. Both variables are based on the industrial census in the year 2012. As previous section, suspected outliers are further deleted according to Cook's distance.

While the average *FOR* is reported in the previous section, *LP* is averaged out at 5.50 million Thai Baht with the maximum of 119.60 million Thai Baht in automobile bodies, trailers and semi-trailers (ISIC3420), and minimum of 0.25 million Thai Baht in musical instrument (ISIC3692). More precisely, only 2 industries, having foreign presence exceed 50 per cent, are ranked in the top-ten highest value added per workers. They are glass and glass products (ISIC2610) and electronic valves, tubes and etc. (ISIC3210), which have value added per workers 14.92 and 11.41 million Thai Baht, respectively.

The scatter plot, in figure 2, indicates insignificantly positive relationship between foreign presence and labor productivity. The spearman correlation is 0.0013 without statistical significance. This finding seems to be in contradict to Hill & Athukorala (1998), which recently argued that FDI in Southeast Asia is efficiency-seeking category. Nonetheless, the employed data are plant-level information during the serious flood in the year 2011. Hence, the data might not reflect the firm operations as under normal situation.

FIGURE II



CORRELATION BETWEEN FOREIGN PRESENCE (*FOR*) AND LABOR PRODUCTIVITY (*LP*)

Note: The statistical relationship between *FOR* and *LP* is not different from zero, based on the simple ordinary least square estimation in which *FOR* and *ERP* are dependent variable and independent variable, respectively. *FOR* is convert into logarithmic form as ln(1+*FOR*), whereas *LP* is the logarithmic transformation of its value.

$$FOR = 0.22 - 0.05ERP$$

(10.69)*** (-0.41)

(t-stat in parenthesis)

Source: Author's compilation. See full data in Appendix.

C. Foreign Direct Investment Flows: Trend and Pattern

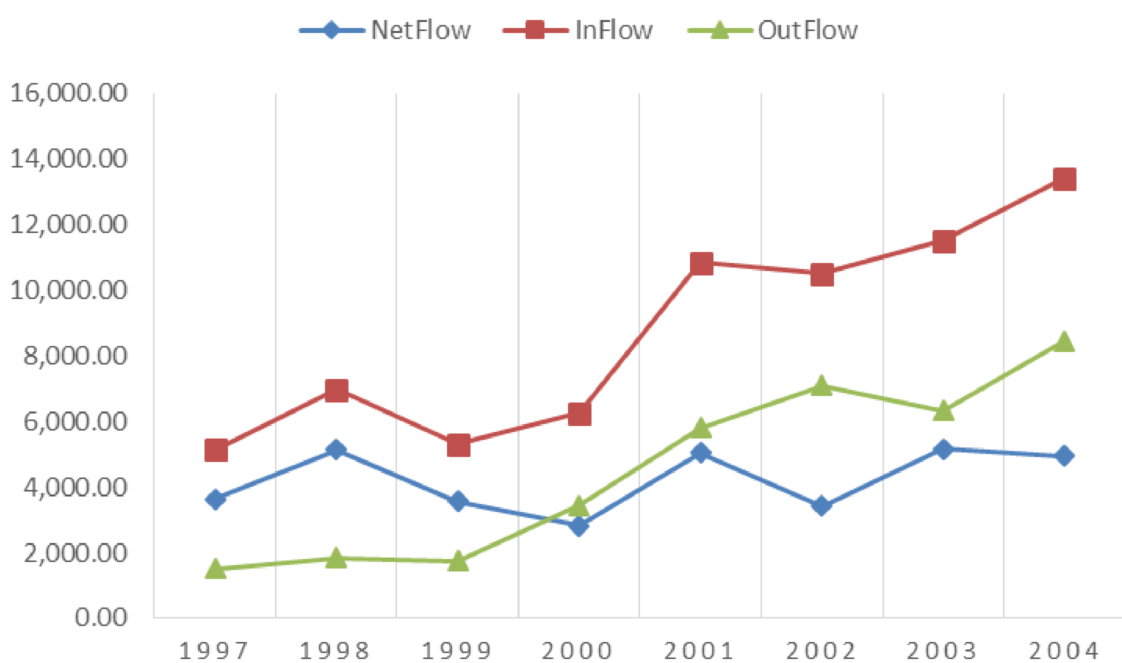
In Thailand, the trend and pattern of FDI flows are dramatically changed after the Asian financial crisis in 1997. In particular, FDI net flows in 1997 rose more than 60 per cent from 1996. This is mostly due to sharp exchange rate depreciation, lower property prices and more company assets offered for sale, in the wake of economic turmoil (UNCTAD, 1988). This study starts illustrating the trend and pattern of FDI since the post-1997 crisis, accordingly. To do that, the data provided by the Bank of Thailand (BOT)[7] are employed, which is the most reliable FDI data so far. Nonetheless, the long series of data covering FDI flows over 1997-present has not been available, particularly there are two available series, i.e. over 1997-2004 and 2005-2014. Those series of data are differently classified. For example, FDI flows series over 1997-2004 excludes non-bank activities, whereas the new series has included them. Under this circumstance, the analysis in this section has to be separated into two periods of analysis.

Between the years 1997-2000, there were the highest FDI net flow and inflow in 1998. As a result of financial crisis in 1997, the currency depreciation attracted foreign direct investment and induced debt-to-equity conversion (Jantarangs, 2004). Parent companies had to increase their affiliates' capitals due to the floating exchange rate policy as well as the credit crunch. In addition, there was a dramatic increase in mergers and acquisitions (M&A), since

[7] In specific, BOT gathers activities of direct investors, including investing in equity capital, lending to affiliates, reinvested earnings, debt securities and trade credit among affiliates. The BOT follows consensus defined by IMF and OECD, particularly direct investors are defined as one owning 10 per cent or more of voting shares for an enterprise or the equivalent for an unincorporated enterprise.

foreign firms took over Thai firms facing severe debt and liquidity problems (Puapan, 2014). Nonetheless, the capital outflows started sharply rising since the year 2000, particularly it led to the lowest FDI net flow in the series. This is due to equity-to-debt conversion, buying-back through local firms and paybacks to funds buying asset from Financial Sector Restructuring Authority. The FDI inflow, started increasing again in 2001, mostly was through equity investment, which stopped the downturn of FDI net flow.

FIGURE III

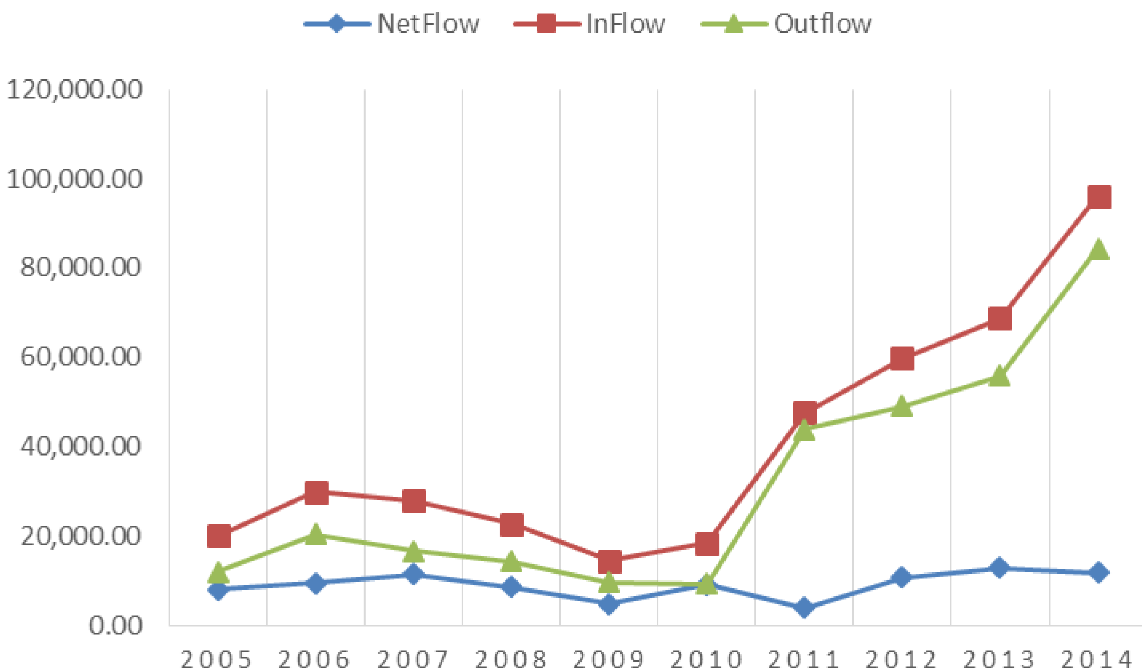


FDI FLOWS IN THAILAND OVER 1997-2004

Source: The Bank of Thailand.
Note: Unit in vertical axis is millions of US dollar. Conversion to US$ equivalent is based on monthly New York closing average exchange rate.

As mentioned above, FDI flows in the series 2005-2014 are extremely higher than the recent series, since FDI flows relating to bank activities have been included in the new series. Over 2005 – 2010, the flows are relatively more stable than the period 2011 – 2014. The subprime crisis has not permanently hurt FDI, particularly there was sharp decline in FDI inflow only in the automotive industry in 2009. After that, the net flow recovered in the next year. Interestingly, while Thailand experienced serious flood in 2011, both FDI inflow and outflow rose dramatically and kept increasing into the new trend. Under this circumstance, FDI net flow dropped to the lowest level. However, the FDI net flow, since 2012, remains into the same path as of the period 2005 – 2010, due to slower rise of FDI outflow. This is largely because Japanese direct investors return to heavily invested in Thai manufacturing, after generating negative net flow in 2011

FIGURE IV



FDI FLOWS IN THAILAND OVER 2005-2014

Source: The Bank of Thailand.
Note: Unit in vertical axis is millions of US dollar. Conversion to US$ equivalent is based on monthly New York closing average exchange rate.

The Board of Investment of Thailand (BOI) is authorized to grant both tax and non-tax incentives in order to attract FDI. Recently, BOI provided area-based incentives, whereas the board has revised the investment promotion policies and criteria. According to the announcement of the Board of Investment No.2/B.E.2557, BOI rotates to grant activity-based and merit-based incentives. Regarding the activity-based incentive, the board classifies two groups of incentives based on the importance of activities, i.e. Group A and Group B. While the former consists of activities which shall receive corporate income tax incentives, machinery and raw material import duty incentives and other non-tax incentives, activities in the latter shall receive only import duty incentives and other non-tax incentives. In general, Group B is activities using low technology and simple production, whereas activities in Group A employing relatively higher technology and more complicated production. Furthermore, in order to attract and stimulate more investment and expenditure on activities benefiting the country or industry at large, the board also offer other incentives based on merits of projects. For example, those include projects involving research and development in technology and innovation, donations to approved activities and organizations, advanced technology training, development of local suppliers, and product and packaging design. In addition, decentralization merits are also emphasized. Under this circumstance, additional incentives will be provided to projects locating in twenty provinces with low per capita income, special economic development zone and approved science and technology parks.

IV. EMPIRICAL ANALYSIS

A. The Model

A.1 The presence of FDI technology spillovers: Structural Equation

The empirical studies of FDI spillovers could generally be categorized into three types, as discussed in Jefferson & Ouyang (2014). The first is the case-study research, which can offer a huge description on episode, which may obviously illustrate general issues. However, case studies often employ only qualitative analysis, which might not allow them to gain insights derived from quantitative analysis. Second, industry-level studies, pioneered by Caves (1974), usually found a positive correlation between FDI inflows and local firm productivity. Nonetheless, it is likely that a positive one is generated by highly productive industries attracting multinational corporations, or presences of FDI drive away weak firms. Industry-level studies are susceptible to endogeneity and spurious inference of causality of critical firm effect, accordingly. The third category of FDI spillovers study is firm-level data. In particular, it is able to maintain quantitative insights, and directly examines the relationship between existing local firms and FDI presence, thereby the firm-level data are preferable and employed in this study.

Most firm-level studies investigating the presence of FDI spillovers usually analyze by the production function framework, particularly the function of locally owned enterprises. Then, the variables relating to FDI spillovers and determinants of firm's productivity are introduced in the production function, namely controlling variables. Moreover, while there are two functional forms of production function often used, i.e. Cobb-Douglas form and Trans-log functional form[8]. In this study, the latter is chosen, in order to make the model be free from certain restrictions imposed in the Cobb-Douglas one, such as unity of elasticity of substitution and log-linear relationship between inputs and outputs. In the Trans-log functional form, output is a function of inputs factors, interaction term between factors and their squared terms to capture any possible non-linear effect as specified in equation (1);

$$lnY_{ij} = \beta_0 + \beta_1 lnK_{ij} + \beta_2 lnL_{ij} + \beta_3 lnK_{ij} lnL_{ij} + \beta_4 (lnL_{ij})^2 + \beta_5 (lnK_{ij})^2 + \beta_6 X_{ij} \quad (1)$$

Where Y_{ij} = value added of local plant *i* of industry *j*

L_{ij} = number of worker of local plant *i* of industry *j*

K_{ij} = fixed assets of local plant *i* of industry *j*

X_{ij} = controlling variables in affecting local plant *i*'s productivity of industry *j*.

In equation (1), there are two primary inputs, namely physical capital (i.e. the plant's fixed assets) and labor, where controlling variables (X_{ij}) include both firm- and industry-specific factors.

The first controlling variable is the plants' market orient nature (MKT_{ij}). As argued in several literatures[9], international market could exert firm heterogeneity in productivity. That is, the exporting firms are found that they are relatively more productive than the remainder. In addition, there is ongoing debate regarding the casual effect of export on productivity. Specifically, the productivity advantage could be generated by either boosting the productivity before export (self-selection), or experiencing productivity gains during export (learning from export). In empirical studies, MKT_{ij} is often measured by two alternative proxies. The first is a binary dummy variable which equals to 1 when plants export ratio is greater than 25 per cent, and zero otherwise. The alternative is the plant's export-sale ratio. While the latter seems to be more theoretical robust, the rationale of using the former is based on the fact that export could lead to higher plant's productivity, regardless of export-sale ratio. Therefore, the binary dummy is used, and the expected coefficient corresponding to MKT_{ij} is theoretically positive.

In this study, as suggested by the theoretical concepts and earlier empirical literatures relating to the determinant of firms' productivity, two industry-specific factors are considered. They are producer concentration and trade policy regime. The producer concentration (CON_j) is often used by policy makers to signal the intensity of product market competition, and to justify any action in preventing any possibly anti-competitive behaviors (Kohpaiboon & Jongwanich, 2013). Nonetheless, the effect of the producer concentration is inconclusive. On the one hand, perfect competition is not necessarily favorable for productivity improvement. This is because productivity-enhancing activities involve large fixed and sunk costs, associated with the large degree of risk and uncertainty. So that, *ex post* market power is needed as incentive to invest in such activities. On the other hand, the required market power is not a sufficient condition for committing to these activities (Symeonidis, 1996; and Ahn, 2002). These activities are not costless, thereby the certain degree of market competition is needed to induce the firm to speed up the adoption of new technology (Porter, 1990; and Aghion et al, 1999). In many cases, productivity improvement could be shrunk by high level of producer concentration(CON_j).

[8] For example, Cobb-Douglas is used by Javorcik (2004); Kohpaiboon (2006b); Kugler (2006); Blalock & Gertler (2008); and Minh et al. (2014). Trans-log is used by Marcin (2008); and Kohpaiboon & Jongwanich (2013).

[9] See Wagner (2007); De Loecker (2007); Greenaway & Kneller (2008); Muûls & Pisu (2009); Cassama et al. (2010); Wagner (2012); and Kasahara & Lapham (2013).

In Thai context, the econometric findings in several studies pointed out that the firm, in high concentrated industry, is relatively more productive than the remainder, regardless of the used proxy. [10] Therefore, in this study, $CR4_j$ (i.e. the output shares of the four largest firms in each industry) is employed as the proxy for CON_j, and the coefficient corresponding to CON_j is theoretically expected to be either positive or negative impact.

The second industry-specific factor is the trade policy regime. A number of papers[11] argues that high protection would hurt the firms' productivity because high trade protection can creates policy-induced economic rent. In particular, the producers may become unresponsive to improve their technological capability, or even may not enhance their product quality to be suitable with a sale price. In other words, this evidence also support that liberalizing trade policy would induce the firms to be more productive. In contrast, there is an empirical evidence pointed out that liberalizing the trade policy could reduce the firms' productivity (see Yu et al., 2013). Additionally, the trade protection are usually proxied by either nominal rate of protection (NRP) or effective rate of protection (ERP). Nonetheless, Jongwanich & Kohpaiboon (2007) found that, based on the econometric evidence, the political bargains in Thai manufacturing are struck over ERP rather than NRP. So that, this study employs ERP as the proxy for trade protection. Hence, the coefficient corresponding to TP_j is theoretically expected to be either positive or negative.

Following Kohpaiboon & Jongwanich (2013), an interaction term between CON_j and TP_j is introduced to rectify the major weakness of producer concentration in measuring the degree of product market competition. In some case, the producer concentration is unable to capture dynamic aspect of competition especially from imports. As mentioned above, competition is important for the productivity improvement activity. In the competitive environment, the less productive firms tend to be "weeded out", so that a highly concentrated industry structure would be more conducive for firms to continue their innovative activities. By contrast, in the absence of significant market competition, economic rents generated as a result of high producer concentration are likely to be captured by its managers (and workers) in the form of managerial slack, or lack of effort. All in all, this suggests that the impact of producer concentration tends to be conditioned by the degree of produces statistical negative on local firms' productivity, significantly. Hence, the interaction term between CON_j and TP_j is examined as controlling variable with the negative theoretically-expected impact.

The extent of foreign presence in an industry j (FOR_j) is introduced to examine intra-industry spillovers. In earlier studies, foreign presence is proxied by either capital shares, employment, or output. In this study, FOR_j is measured by the share of an industry's output produced by foreign affiliates. This is due to 2 reasons. First, measuring by the capital shares could be distorted, because of the foreign ownership restrictions in Thailand. Second, most foreign affiliates tend to be more capital intensive than local firms, thereby measuring by employment shares tends to underestimate the foreign presence. FOR_j is measured by a following equation:

$$FOR_j = \frac{\left[\sum_{i\ for\ all\ i\epsilon j} ForeignFirm_i * Y_i\right]}{\sum_{i\ for\ all\ i\epsilon j} Y_i} \tag{2}$$

where $ForeignFirm_i$ is a dummy variable equals to one, if the firm is foreign affiliate (i.e. foreign share is greater than 10per cent) and zero otherwise. As discussed, the demonstration effect could lead to productive enhancement of local firms, while the competition generated by foreign affiliate may hurt local firms' productivity. Hence, either positive or negative sign of FOR_j is theoretically expected.

As discussed, absorptive capability and trade policy regime could condition the technological gain through intra-industry FDI spillovers, i.e. the assumption of heterogeneous horizontal spillovers. In this study, absorptive capability is examined by an interaction term between FOR_j and QL_{ij}. Specifically, QL_{ij} is measured by the ratio of supervisory and management workers to total employment. Supervisory and management workers are regards as skilled labor, thereby the higher the ratio, the higher the labor quality. The more the capacity to learn the advanced technology. Hence, the expected sign of the corresponding coefficient is positive.

[10] CR4, CR5, HHI are employed by Kohpaiboon (2006b); Kohpaiboon & Jongwanich (2013); and Srithanpong (2014)
[11] De Melo & Urata (1996); Moran (2001); De Loecker (2011); Topalova & Khandelwal (2011); and Buccirossi (2013).

The role of trade policy as conditional gains of FDI spillovers is often regarded as Bhagwati hypothesis. The empirical papers, eventually testing this hypothesis, are sparse. While the empirical findings in all studies[12] support Bhagwati hypothesis, there are 2 methods for testing the hypothesis. First, Kokko et al. (2001) uses the year 1973, where Uruguay embarked on trade liberalization reform, as a benchmark in classifying the FDI under restrict and liberal trade policies. However, using the base year is problematic. This is because there were some industries continued to remain under heavy protection, in the years after implementing that reform (Favaro & Spiller, 1991). So that, this study follows the second method used in Kohpaiboon (2006b) and Kohpaiboon & Jongwanich (2013). In particular, both studies employ an interaction term between foreign presence (FOR_j) and trade protection (TP_j). As mentioned, it is likely that the local firm under liberal trade policy are more productive than the remainder. Hence, the negative sign of coefficient corresponding to this interaction term is theoretically expected.

The consensus has not been reached on how the linkages should be measured, i.e. the proxies for vertical spillovers. Currently, there are 2 measures eventually used in the empirical studies. That is, the measures of Javorcik (2004) versus the measures of Kohpaiboon & Jongwanich (2013). In specific, the first measures capture only direct linkages, whereas the second ones capture both direct and indirect linkages. Interestingly, while the empirical models using the former emphasize the role of vertical spillovers, the latter could not find any evidence of inter-industry FDI spillovers. That is why this study purposes to systematically examine vertical spillovers, i.e. both measures are simultaneously used, in this study.

The measures of Javorcik (2004), namely standard measures, are the proxies for vertical spillovers. On the one hand, $BACK$ is intended to capture the extent of potential contacts between domestic suppliers and multinational customers, i.e. the proxy for backward linkage effects:

$$BACK\_std_j = \sum_{k\ if\ k \neq j} \alpha_{jk} FOR_k \tag{3}$$

where α_{jk} is the proportion of sector *j*'s intermediate output supplied to sector *k*. The proportion includes only the intermediate product supplied within Thai manufacturing, i.e. the products supplied for final demand and imported products are excluded.

On the other hand, $FORW$ captures the activities in which intermediate output produced by multinational firms supplied to local customers, i.e. the proxy for forward linkage effects:

$$FORW\_std_j = \sum_{m\ if\ m \neq j} \sigma_{jm} FOR_m \tag{4}$$

where σ_{jm} is the proportion of intermediate output produced by sector *m*, which are purchased by sector *j*. As previous measure, this proportion includes only the intermediate products purchased within Thai manufacturing. Importantly, as equation (3) and (4) illustrate, both α_{jk} and σ_{jm} capture only the direct linkages between indigenous suppliers and multinational customers, and vice versa.
The measures of Kohpaiboon & Jongwanich (2013), namely alternative measures, are initially conducted with the identical concept as the recent measures. The measures aim to measure the linkages between foreign affiliates and local firms. $BACK$ is alternatively measured by:

$$BACK\_alt_j = \sum_{k\ if\ k \neq j} \delta_{jk} FOR_k \tag{5}$$

Meanwhile, $FORW$ is alternatively measured by:

$$FORW\_alt_j = \sum_{m\ if\ m \neq j} \varphi_{jm} FOR_m \tag{6}$$

[12] Kokko et al. (2001) studies the case of Uruguay. Kohpaiboon (2006b) and Kohpaiboon & Jongwanich (2013) study the case of Thailand.

Both δ_{jk} and φ_{mj} are different from α_{jk} and σ_{jm}, respectively. In particular, they are derived according to the Leontief inter-industry accounting framework. Firstly, the input-output table is conducted in the form of equation (7), i.e. the import content of each transaction is separately identified and allocated to an import matrix:

$$X = A^d X + Y^d + E \tag{7}$$

where X is column vector of total gross output, $A^d = \left[a_{ij}^d\right]_n$ in which $a_{ij}^d = X_{ij}/X_j$ is domestic input-output coefficient matrix, Y^d is column vector of domestic demand on domestically produced goods, and E is column vector of export demand on domestically produced goods. In the next step, equation (7) is solved for X as equation (8):

$$X = (1 - A^d)^{-1}[Y^d + E] \tag{8}$$

where $(1 - A^d)^{-1}$ is the Leontief domestic inverse (LDI) matrix. Finally, δ_{jk} is an element in a row vector j of the matrix, which indicates amount of industry j's output demanded by an additional unit of industry k's output produced, i.e. the derived demand for industry j's output from industry k's output produced. On the other hand, φ_{mj} is an element in a column vector j in LDI matrix, which indicates demand for industry m's output to be used as inputs for producing a unit of industry j's output. Importantly, δ_{jk} and φ_{mj} capture both direct and indirect (inter-sectoral) repercussion. As discussed, the higher $BACK$ and $FORW$, the more likely the presence of vertical spillovers. Therefore, the positive signs of both $BACK$ and $FORW$ are theoretically expected.

A.2 The presence of FDI: Reduced-Form Equation

The literatures examining the presence of FDI spillovers are often criticized on a possibility of a simultaneity problem. In particular, the positive relationship between foreign presence and firms' productivity (i.e. FOR_j and Y_{ij}) might reflect the fact that foreign affiliate prefers to invest in more productive industries, rather than representing the presence of FDI technology spillovers (Haddad & Harrison, 1993; and Atiken & Harrison, 1999). In this study, the possibility of simultaneity bias is mitigated by replacing a suspected endogenous variable (i.e. FOR_j) with instrumental variables (IV). So that, instruments for reduced-form equation are needed to explore. There are 3 factors, which have been widely used in previous empirical studies on FDI determinants. Specifically, FOR_j is a function of market size, tariff barrier, and labor quality.

Since one of the objectives of FDI, in developing countries, is to reap benefit from domestic market, the market size ($MSIZE_j$) may determine the foreign presence (Sahoo, 2006). So that, it is likely that the industry with a larger market size could attract more FDI, because of more business opportunities (Wang & Swain, 1995; and Moore, 1993).

As argued by Lim (2001), the presence of FDI might be determined by the trade policy regime. In particular, the horizontal FDI, which are undertaken to get behind trade berries (tariff-hopping), may decline with tariff reduction. In contrast, the vertical FDI may increase from the reduction of tariff, since the vertical ones often requires substantial flows of intermediate inputs across country. In some case, the non-tariff-hopping horizontal FDI may be stimulated to the extent of that trade liberalization could lead to a better business climate as well as expectations of better long term economic growth prospects and increasing market size. So that, TP_j implying tariff barrier is included.

Either $MSIZE_j$ or TP_j alone might not be significant to attract FDI, especially in a small open economy like Thailand (Kohpaiboon, 2006b). It is more appropriate to add an interaction term to capture impact of both factors. Specifically, at a given level of tariff barrier, a larger market could enhance the stimulating impact of tariff protection on the foreign presence. In Thailand, market size might not be large enough to attract a MNE to locate its affiliate and substitute international trade for investment. That is, the impact of market size on FDI determinants depends positively on tariff barriers.

Finally, several FDI determinants literatures often hypothesize that quality of labor will encourage efficiency-seeking FDI inflows. This is because some MNEs locate their affiliates in order to access cheaper, better quality raw material as well as labor to enhance productivity. This study also incorporate the hypothesis by taking the labor quality (QL_j) into the model.

A.3 Summary of the Model

All in all, with respect to the possibility of simultaneity problem, equation (9) and equation (10) are specified as structural equation and reduced-form equation, respectively. The empirical model, in this study, is specified as (theoretically expected signs are given in parenthesis):

$$lnY_{ij} = \gamma_0 + \gamma_1 lnK_{ij} + \gamma_2 lnL_{ij} + \gamma_3 lnK_{ij} lnL_{ij} + \gamma_4 (lnL_{ij})^2 + \gamma_5 (lnK_{ij})^2 + \gamma_6 MKT_{ij} + \gamma_7 CON_j + \gamma_8 TP_j + \gamma_9 CON_j * TP_j + \gamma_{10} FOR_j + \gamma_{11} QL_{ij} * FOR_j + \gamma_{11} TP_j * FOR_j + \gamma_{13} BACK_j + \gamma_{14} FORW_j + \mu_{ij} \quad (9)$$

where

$$FOR_j = \pi_0 + \pi_1 MSIZE_j + \pi_2 TP_j + \pi_3 MSIZE_j * TP_j + \pi_4 QL_j + \nu_j \quad (10)$$

lnY_{ij} = Value added of local plant *i* in industry *j*,

lnK_{ij} = Fixed asset of local plant *i* in industry *j*,

lnL_{ij} = Number of workers of local plant *i* in industry *j*,

MKT_{ij} = Market orientation of local plant *i* in industry *j* measured by binary dummy variable, which equals to 1 if the export-output ratio exceeds 25 per cent and zero otherwise,

CON_j = Producer concentration of industry *j* proxied by $CR4_j$ (+)

TP_j = Trade policy regime in industry *j* proxied by ERP (+/-)

FOR_j = Foreign presence in industry *j* measured by output share of foreign plants to total sales, i.e. presence of horizontal spillovers (+/-),

QL_{ij} = Quality of labor of plant *i* in industry *j* measured by the ratio of supervisory and management workers to total employment,

$QL_{ij} * FOR_j$ = FDI technology spillovers gain conditioned by QL_j, i.e. absorptive capability hypothesis (+),

$TP_j * FOR_j$ = FDI technology spillover gain conditioned by trade policy, i.e. Bhagwati's hypothesis (-),

$BACK_j$ = Backward linkages spillovers through foreign presence to industry alternatively proxied by $BACK\_std_j$ and $BACK\_alt_j$ (+),

$FORW_j$ = Forward linkages spillovers of foreign presence to industry alternatively proxied by $FORW\_std_j$ and $FORW\_alt_j$ (+),

$MSIZE_j$ = Market size of the industry *j* measured by the sun of gross output and (net) import,

QL_j = Labor quality of the industry *j* proxied by the ratio of supervisory and management workers to total industry management,

μ_{ij} = A stochastic error term representing the other influences omitted in structural equation,

ν_j = A stochastic error term representing the other influences omitted in reduced-form equation.

B. Data and Variable Construction

The data set suiting the purpose of this study is long-panel data of establishment in Thai manufacturing. Unfortunately, particular data set is not available in Thailand. So far, only three industrial census[13], which are cross-sectional in nature, are available. These three census are unable to formulate as a panel data set as identification number (ID No.) used in each census is assigned differently, i.e. a given ID No. of two different census is not necessary the same firm. Hence, The Industrial Census gathered by the National Statistical Office of Thailand (NSO), Ministry of Information and Communication Technology, in the year 2012[14], is eventually used.

The used census contains 98,842 observations. The census is first cleaned up by deleting self-employed (i.e. zero record of paid worker) or micro firms (i.e. less than or equal to 10 paid workers). There are 71,387 observations, which are eliminated, thereby the remaining observations are 27,095. As discovered by several literatures[15], there are many duplicate samples in which at least two observations report the same value in most of variables. The

[13] The industrial census in the year 1996, 2006 and 2012.

[14] The census actually contains the firm data in the year 2011.

[15] They are Ramstetter (2004), Kohpaiboon (2006b) and Kohpaiboon & Jongwanich (2013).

criterion, in this study, is that a variable is treated as duplicated sample (will count only 1 sample), if samples report identical values of 7 key variables. The 7 key variables include total paid-workers, female paid-workers, initial fixed asset, ending fixed asset, registered capital, sale values and input values. According to this criterion, there are 4,418 removed samples. The remaining observation is 22,677.

Then, the observations, reporting unrealistic value of the key variables, are dropped. They include negative value added, low value added (i.e. less than 10,000 Thai Baht) and low fixed asset (i.e. less than 10,000 Thai Baht). Finally, 8 industries, which either serve niches in the domestic market[16], in the service sector[17] or explicitly preserved for local enterprises[18], are excluded. All in all, there are 13,593 observations remained.

Value added is defined as the difference between gross output and raw materials net of changes in inventories, whereas capital stock is represented by the value of fixed assets at the initial period. The other information related to plant- and industry-specific variables (i.e. MKT_{ij}, QL_{ij}, $MSIZE_j$ and QL_j) are reported in the survey.

CR4 is obtained from Kohpaiboon & Ramstetter (2008) in which the concentration is measured at the more aggregate level, i.e. many industries are measured at the 4-digit whereas fewer industries are measured at the 3-digit ISIC classification. They do that so as to guard against possible problems arising from the fact that two reasonably substitutable goods are treated as two different industries according to the conventional industrial classification at high level of disaggregation.

ERP are from Jongwanich & Kohpaiboon (2007). Their estimates are based on the data in 2003, which reflect the protection structure in 1997-2003, since there was no major change in tariff during this period. In addition, the used ERP series is the weighted average of import-competing and export-oriented ERP. The latter is referred to ERP estimates for exporters, who are eligible for various tariff rebate programs. Since ERP is based on the input-output (IO) industrial classifications, the official concordance is needed to convert them into 4-digit ISIC. In a case that there is not one-to-one matching in the concordance, the weighted average is applied, using value added as a weight.
FOR_j is constructed using the Industrial Census 2012, particularly all plants with foreign shares being greater than 10 per cent are considered to be foreign instead of local plants. The cutting point (i.e. 10 per cent) follows the International Monetary Fund (IMF), and other institutes such as the Organization for Economic Co-operation and Development (OECD), the US Department of Commence as well as several scholars studying multinational firms (IMF, 1993; Lipsey, 2001).

The ideal dataset for measuring $BACK_j$ and $FORW_j$ is detailed information of inter-enterprises relationship between local and foreign enterprises, i.e. how much the former sells to or buys from the latter. However, this choice is impracticable, as a result of data limitation. Hence, the inter-industry relationship to measure $BACK_j$ and $FORW_j$ is based on Thailand's input-output table in 2005, which is the most up-to-date and reliable IO table, conducted by Office of National Economic and Social Development Board, Office of the Prime Minister. The IO table consists of 180 economic activities[19]. Nonetheless, one caveat, when using Thailand's input-output table, is that car assembly and several metallic parts manufactures such as body parts and inner panels are lumped into a single category, (IO-125: motor vehicle), so that backward linkages measured might be to a certain extent underestimated. The same procedure, applied for ERP, is used to match input-output (IO) industrial classifications to 4-digit ISIC.

As a nature of cross-sectional data, it is likely that outliers could impact on and mislead the estimated parameters, thereby the careful treatment of outliers is needed. In order to eliminate the possible problem, Cook's distance[20] is used to identify suspected outliers. The observations, which are suspected as outlier according to Cook's distance, are further deleted. Table 2 and Table 3 provide a statistical summary of all variables discussed above and their correlation matrix.

TABLE II

[16] e.g. processing of nuclear fuel, manufacture of weapons and ammunition
[17] e.g. building and repairing of ships, manufacture of aircraft and spacecraft, and recycling
[18] e.g. manufacture of ovens, furnaces and furnace burners, manufacture of coke oven products
[19] 42 sectors in agriculture and primary sectors; 93 sectors in the manufacturing sector; and the remainder in the service sector
[20] Cook's distance is the influence statistic developed by Cook (1977). The statistics take into account both the studentized residuals (the residual divided by its standard error) as well as the estimated variances of the residuals to identify outliers. For details, see Belsley et al. (1980) and Barnett & Lewis (1994).

A STATISTICAL SUMMARY OF THE KEY VARIABLES

	Unit	Mean	S.D.	Min	Max
Y_{ij}	(ln) baht	15.70	2.27	9.25	22.52
K_{ij}	(ln) baht	15.70	2.19	9.43	24.15
L_{ij}	(ln) baht	3.63	1.07	2.40	8.98
MKT_{ij}	zero-one dummy	0.07	0.25	0.00	1.00
CON_j	(ln) proportional	0.37	0.06	0.28	0.53
TP_j	(ln) proportional	0.03	0.17	-0.86	0.47
QL_{ij}	(ln) proportional	0.06	0.11	0.00	0.69
FOR_j	(ln) proportional	0.16	0.12	0.00	0.64
$BACK\_std_j$	(ln) proportional	0.10	0.08	0.00	0.36
$FORW\_std_j$	(ln) proportional	0.11	0.07	0.01	0.33
$BACK\_alt_j$	(ln) proportional	0.27	0.34	0.00	1.36
$FORW\_alt_j$	(ln) proportional	0.22	0.11	0.03	0.55
QL_j	(ln) proportional	0.09	0.04	0.00	0.30
$MSIZE_j$	(ln) Thai Baht	24.63	1.15	18.09	27.15

Source: The author's estimation based on the data sources described in the previous chapter.
Note: [a]Mean = Simple average; S.D. = Standard deviation; Min = Minimum; Max = Maximum; [b]Estimates of Y_{ij}, K_{ij} and L_{ij} are the logarithmic transformation of their value. The other variables are converted into logarithmic form as ln(1+*x*) where *x* is the variable.

TABLE III
CORRELATION MATRIX OF THE VARIABLES

	Y_{ij}	L_{ij}	K_{ij}	MKT_{ij}	CON_j	TP_j	QL_{ij}	FOR_j	$BACK\_std_j$	$FORW\_std_j$	$BACK\_alt_j$	$FORW\_alt_j$	QL_j	$MSIZE_j$
Y_{ij}	1.00													
L_{ij}	0.66	1.00												
K_{ij}	0.82	0.59	1.00											
MKT_{ij}	0.25	0.31	0.22	1.00										
CON_j	0.04	0.00	0.07	0.00	1.00									
TP_j	0.02	-0.01	0.01	0.00	0.08	1.00								
QL_{ij}	0.30	0.15	0.24	0.08	0.03	0.04	1.00							
FOR_j	0.08	0.07	0.03	-0.02	-0.16	0.06	0.02	1.00						
$BACK\_st$	-0.04	-0.01	-0.06	-0.02	-0.34	0.10	0.01	0.15	1.00					
$FORW\_st$	-0.02	-0.01	-0.06	-0.02	-0.14	0.24	0.00	0.23	0.17	1.00				
$BACK\_al$	0.09	0.03	0.07	-0.04	-0.20	0.06	0.07	0.28	0.65	-0.04	1.00			
$FORW\_a$	0.10	0.04	0.05	-0.02	-0.08	0.31	0.04	0.47	0.13	0.81	0.17	1.00		

QL_j	0.21	0.04	0.21	-0.01	0.32	-0.01	0.13	0.09	-0.22	0.01	0.01	0.04	1.00	
$MSIZE_j$	0.15	0.11	0.14	0.03	-0.15	-0.31	0.03	0.08	-0.20	-0.12	0.05	-0.04	0.07	1.00

Source: The author's estimations based on the data sources described.

C. Econometric Procedure

The equations are initially estimated by using the ordinary least square (OLS) method. Unbiasedness and consistency of OLS estimates rest on the assumption that the explanatory variables are uncorrelated with the stochastic disturbance terms. This assumption becomes invalid for any individual equation in a system of equations whenever at least one of the explanatory variables of that equation is jointly-determined and making the use of OLS inappropriate. In this study, FOR_j is suspected as endogenous variable, as it is likely that simultaneous relationship between FOR_j and Y_{ij} may arises. The alternative estimators, devised to be used in this situation, fall into two main categories, i.e. system methods and single-equation methods. The system methods, of which three stage least squares (3SLS) and full-information maximum likelihood (FIML) are best known, and are superior to the single-equation methods in terms of efficiency of the estimates. However, while using 3SLS or FIML, all equations in the system must be properly specified. Since these methods utilize information on the interconnection among all the equations in the system, what is happening elsewhere in the system will be transmitted throughout the whole system, which cause biases and distortions. Based on a Monte Carlo experiment of a finite sample, 2SLS has emerged as a good compromise choice among available alternatives. 2SLS, generally performing well in terms of both bias and mean-squared error, shows a relatively higher degree of stability and is not greatly affected by specification (Intriligator et al. 1996: pp.389). Moreover, 2SLS and 3SLS estimates are equivalent asymptotically (Wooldridge 2002: pp.199). Hence, 2SLS is chosen for solving suspected simultaneity problem.

2SLS involves applying OLS in two stages. The first stage involves regressing each of the explanatory endogenous variables on all the pre-determined variables. In the second stage, the fitted values of the explanatory endogenous variables, obtained from the first regression, are used in place of their observed values to estimate the structural form coefficients. This two-stage procedure avoids the simple one-stage least square bias and inconsistency in the estimates by eliminating from the explanatory endogenous variables that part of the variation is due to the disturbance.

D. Econometric Results

The regression results, relating to the determinants of the local firms' productivity, are reported in Table 4. As mentioned above, the studies of FDI spillovers are subject to a criticism about possibility of a simultaneity problem. The general response, in this study, is to undertake 2SLS method. Equation 4.1 - 4.4 and 4.5 - 4.8 represent OLS and 2SLS estimates, respectively. As one of the main purposes of this study, the different measures of vertical spillovers are systematically examined. So that, $BACK_j$ and $FORW_j$, based on standard measure (i.e. measures capturing only direct linkages), are proxied in equations 4.1 – 4.2 and 4.5 - 4.6. In contrast, the alternative measures (i.e. the measures capturing both direct and indirect linkages) are proxied in equations 4.3 - 4.4 and 4.7 – 4.8. On the other hand, the importance of the determinants of horizontal spillovers on empirical finding are also examined. To do that, the determinants of FDI spillovers are included in equations 4.2, 4.4, 4.6 and 4.8 (i.e. the assumption of heterogenous horizontal spillovers; HHS), while the remainder omits the determinants (i.e. the assumption of identical horizontal spillovers; IHS).

TABLE IV
REGRESSION RESULTS

	OLS				2SLS			
	Std. Measures		Alt. Measures		Std. Measures		Alt. Measure	
	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8
	IHS	HHS	IHS	HHS	IHS	HHS	HIS	HHS
Intercept	-6.25	-5.63	-6.23	-5.71	-5.71	-5.00	-6.21	-5.78

	(-19.75)***	(-17.57)***	(-19.86)***	(-18.01)***	(-14.93)***	(-12.28)***	(-13.85)***	(-17.01)***
lnL_{ij}	0.72 (9.15)***	0.67 (8.65)***	0.75 (9.77)***	(9.29)***	0.84 (9.12)***	0.91 (9.36)***	0.88 (7.90)***	0.82 (9.70)***
lnK_{ij}	1.86 (43.23)***	1.80 (41.63)***	1.81 (42.30)***	1.77 (41.03)***	1.64 (30.81)***	1.56 (26.55)***	1.71 (28.04)***	1.71 (35.93)***
$lnL_{ij} lnK_{ij}$	0.01 (2.06)**	0.01 (1.29)	0.01 (1.56)	0.01 (0.77)	-0.02 (-0.94)*	-0.01 (-1.12)	-0.01 (-1.45)	-0.01 (-0.66)
$(lnL_{ij})^2$	-0.04 (-4.93)***	-0.02 (-2.91)***	-0.03 (-4.58)***	-0.02 (-2.56)**	-0.02 (-1.68)	-0.02 (-2.28)**	-0.01 (-0.91)	-0.02 (-2.13)**
$(lnK_{ij})^2$	-0.04 (-22.31)***	-0.04 (-21.11)***	-0.04 (-21.49)***	-0.04 (-20.52)***	-0.03 (-13.78)***	-0.03 (-11.22)***	-0.03 (-11.84)***	-0.03 (-15.99)***
MKT_{ij}	0.22 (8.15)***	0.21 (7.86)***	0.25 (9.47)***	0.24 (8.81)***	0.21 (5.71)***	0.21 (5.68)***	0.10 (2.01)**	0.20 (6.34)***
CON_j	-0.30 (-2.00)**	-0.22 (-1.46)	0.16 (1.17)	0.19 (1.28)	0.68 (3.39)***	-0.39 (-1.58)	0.51 (2.13)**	0.07 (0.38)
TP_j	-1.49 (-4.06)***	-1.91 (-5.24)***	-0.80 (-2.15)**	-1.23 (-3.34)***	-2.95 (-5.04)***	-2.51 (-3.07)***	-6.71 (-6.29)***	-2.79 (-4.39)***
$CON_j TP_j$	4.55 (4.52)***	4.34 (4.16)***	2.01 (1.97)**	1.83 (1.75)*	8.53 (5.16)***	16.40 (5.74)***	20.74 (7.12)***	11.55 (4.52)***
FOR_j	0.62 (9.29)***	-0.22 (-2.77)***	0.01 (0.05)	-0.79 (-9.24)***	7.07 (14.58)***	7.88 (8.58)***	11.53 (10.40)***	4.14 (4.21)***
$BACK\_std_j$	0.01 (0.07)	0.04 (0.36)			-0.78 (-5.11)***	-1.98 (-7.63)***		
$FORW\_std$	-0.02 (-0.11)	0.04 (0.30)			-2.56 (-9.67)***	-2.16 (-6.15)***		
$BACK\_alt_j$			0.25 (10.05)***	0.23 (9.47)***			-0.54 (-6.04)***	-0.08 (-0.53)
$FORW\_alt_j$			0.92 (10.23)***	0.85 (9.43)***			-5.47 (-8.18)***	-1.05 (-1.76)***
$FOR_j TP_j$		2.58 (5.91)***		2.81 (6.73)***		-18.89 (-8.11)***		-7.07 (-3.54)***
$FOR_j QL_j$		8.94 (25.95)***		8.86 (26.29)***		-3.34 (-2.12)**		2.70 (2.08)**
# Observation	18,483	18,486	18,466	18,453	18,483	18,486	18,466	18,453
# Outlier	1,048	1,045	1,065	1,078	1,048	1,045	1,065	1,078
F-stat	4,894.87***	4.216.70***	4,956.50***	4,273.25***				
Wald chi-sq					39,898.74***	39.987.03***	28,599.58***	31,210.52***
R-squared	0.74	0.74	0.74	0.74	0.63	0.63	0.46	0.71
Geary	-18.65 (p=0.00)	-20.01 (p=0.00)	-18.96 (p=0.00)	-19.17 (p=0.00)	-40.75 (p=0.00)	-37.94 (p=0.00)	-54.21 (p=0.00)	-27.99 (p=0.00)
White	443.50	451.51	461.07	452.92	155.95	340.07	872.21	279.23

	(p=0.00)	(p=0.00)	(p=0.00)	(p=0.00)	(p=0.00)	(p=0.00)	(p=0.00)	(p=0.00)
RESET	96.07	127.65	93.19	121.39	6.43	24.53	0.77	43.57
	(p=0.00)	(p=0.00)	(p=0.00)	(p=0.00)	(p=0.01)	(p=0.00)	(p=0.38)	(p=0.00)
Overid					17.84	62.76	3.53	185.12
					(p=0.00)	(p=0.00)	(p=0.17)	(p=0.00)

Note: Number in parenthesis are t-statistics and z-statistic for OLS and 2SLS constructed from robust standard error, respectively. ***, ** and * indicate the level of statistical significance at 1, 5 and 10per cent, respectively. OLS = Ordinary Least Square and 2SLS = Two-Stage Least Square. Std. Measures is the measures including only direct linkages, whereas Alt. Measures is the measures including both direct and indirect linkages. IHS = Identical Horizontal Spillover (i.e. omitting the determinants of horizontal spillovers), while HHS = Heterogeneous Horizontal Spillovers (i.e. including the determinants). Geary = Geary Non-Normality LM Runs Test; White = White Test for the heteroscedasticity (F-distribution); RESET = Ramsey RESET Test functional form misspecification (F-distribution and Chi-squared distribution for OLS and 2SLS, respectively); Overid = Overidentification Test (Chi-squared distribution).
Source: The author's estimation based on the data sources described in the previous chapter.

As Table IV illustrates, all regressed equations pass the overall statistical significance at the 1 per cent level. Most coefficients corresponding to the interaction term between labor and capital, labor squared as well as capital squared are statistically significant. These results eventually suggests that the trans-log functional form well fit the data as opposed to Cobb-Douglas one, which omits both interaction and squared terms. In addition, Trans-log functional form specification is often doubted that the function is likely to be distorted by the multicollinearity problem and inflated standard error. Nonetheless, the statistical significances suggest that such a multicollinearity problem would not create any severe effect in the regression outcome.

Unsurprisingly, the sign of coefficient corresponding to MKT_{ij} turns out to be significantly positive. This result is in line with the theoretical hypothesis and the findings in earlier studies. In other words, the data indicate that exporting firms are likely to exhibit a higher level of productivity than non-exporting ones. That is, this finding supports the consensus in the literature of export-productivity nexus, i.e. the export-oriented plants tend to be more productivity than the remainders.

The coefficients corresponding to CON_j vary from equation to other equations, where most coefficients turn out to be statistically insignificance. This might due to the impact of producer on the plant's productivity, which is not automatic but might depends on the degree of tariff protection. On the other hand, liberalizing trade policy could induce the firms to be more productive as the coefficients corresponding to TP_j turn out to be significantly positive.
The coefficients corresponding to the interaction term between CON_j and ERP_j are different from an expectation. They are positive and statistically significance, even the negative sign is theoretically hypothesized. Nonetheless, the hypothesis, in which the high protection tends to induce producer to become unresponsive to improve their technological capacity and retard productivity growth, have not been rejected. Instead, the outcome might imply that, in the current situation, the plants under high protection as well as high producer concentration are relatively more productive than the remainders as the results of the protection-induced economic rents as well as high market power. Given improving technological capabilities is needed in sustaining productivity, the hypothesis should be tested by concentrating on technological improvement activity, instead of the current firm's productivity.

The following discussion will be based on the variables relating to FDI technology spillovers. On the one hand, while both OLS and 2SLS are reported, the latter is more preferable, due to 2 reasons. First, the analysis may suffer simultaneity relationship between the foreign presence and the productivity of the local firms. Second, only the interaction terms between FOR_j and TP_j, estimated by 2SLS method, are statistically significant with the theoretically expected sign. This evidence could support the existence of simultaneity problem. Furthermore, the interaction terms between FOR_j and TP_j, as well as FOR_j and QL_j (i.e. the determinants of FDI spillovers) are statistically significant at 99 per cent. This supports that horizontal FDI spillovers can vary across industry. So that, suppressing the determinants of horizontal spillovers could lead to biased estimates (i.e. omitted variable problem). Hence, the following discussion will be based on the results in the columns 4.6 and 4.8.

The coefficients corresponding to FOR_j turn out to be positive and statistically significance regardless of the measurement of inter-industry spillovers. It is likely that intra-industry spillovers, in Thai manufacturing, have arisen. This finding is in line with the most recent finding, examined by Srithanpong (2014).[21] The negative coefficients of the interaction term between FOR_j and TP_j in both equations fail to reject the Bhagwati hypothesis, which expressed that locally owned plants, operating in industries with more liberal trade regimes, exhibit relatively more productive than the reminders. The coefficients corresponding to the interaction term between FOR_j and QL_j are not stable. This particular results are not crucial to prove or disprove the absorptive capability hypothesis. One of the shortcoming could be generated by a measuring problem. In particular, the measure of QL_j may be overestimated. This is because the definition of non-production workers, in the census, covers not only supervisory and management workers but also clerical and administrative staffs.

The coefficients corresponding to $BACK\_std_j$ as well as $FORW\_std_j$ turn out to be counterintuitive. They are negative and statistically significant. Nonetheless, the findings do not necessarily reflect the negative impacts through the linkage effect. This is because the data employed are the firm data in the year 2011, which during the serious floods in Thailand. In many cases, several foreign firms could not run their production processes. Under this circumstance, the foreign firms had to delay purchasing intermediate outputs and were unable to supply their outputs. So that, the productivity of local firms, which had the linkages with foreign ones, were further hurt by this unexpected disaster.
Finally, the coefficients corresponding to $BACK\_alt_j$ is statistically insignificant, while $FORW\_alt_j$ is significantly negative with relatively low magnitude. The results indicate relatively low or even zero impacts. Importantly, this findings could indicate that vertical spillovers, in Thai manufacturing, are transmitted mostly through the direct linkage.

V. Conclusion and Policy Inference

This study examines FDI spillovers in Thai manufacturing, using industrial census in the year 2012. A cross-sectional econometric analysis of plant productivity determinants of indigenous plants is undertaken. The paper goes beyond the existing literature in two ways. First, the model are systematically examined, using both the measures of direct linkages and the measures of both direct and indirect linkages. Second, the paper systematically tested the assumptions relating to the determinants of horizontal spillovers, i.e. both assumptions of identical- and heterogenous-horizontal spillovers are studied, simultaneously.

The key finding is that the evidence of horizontal spillovers is found, where the intra-industry technological gains are conditioned by the trade policy regime. The more the liberal trade policy, the more the technological gains through intra-industry spillovers. The finding that export-oriented plants have higher productivity than domestic-market-oriented ones further emphasize the role of liberal trade policy regime on plant productivity improvement process. Trade liberalization, inducing contestability environment, is an effective catalyst for firm to continually improve their productivity. Beside, only in tariff environment, the positive impact of producer concentration on plant productivity is observed[22]. Significant impacts through backward and forward linkage effects are found only in the standard measures, which capture only direct linkage. This findings are in line with earlier studies. In contrast, implementing the alternative measure, which include both direct and indirect linkages, are unable to find the strong evidence of inter-industry spillovers. Interestingly, the findings point out that MNEs, in Thai manufacturing, play an important role on vertical spillovers, mostly in direct-linkages channel.

Two policy inferences can be drawn from this study. First, the results support the relative importance of the trade policy regime for productivity enhancement and development policy. Trade policy regime could create contestability environment, that is, conducive for firm to continue improving their productivity. Second, both direct and indirect linkages should be emphasized, in order to maximize the gains through vertical spillovers. The impacts of MNEs towards the local firms operating in the other industry could be transmitted only through the direct linkage, at least in Thai manufacturing, as shown in empirical results.

Finally, this study ends up with 2 recommendations for further study in this area. First, the assumption of heterogenous horizontal spillovers is more appropriate in the model studying FDI spillovers. Since the determinant of FDI spillover is significant, imposing the assumption of identical horizontal spillovers could lead to biased

[21] Srithanpong (2014) uses the data in the year and found the evidence of horizontal spillovers, whereas the earlier data employed by Kohpaiboon (2006) and Kohpaiboon & Jongwanich (2013) do not indicate particular evidence.
[22] According to Kohpaiboon & Jongwanich (2013).

estimates. Second, the actual gains though vertical spillovers should be investigated by capturing both direct and indirect linkages in the measures, rather than being strict only on the former. The exact roles of MNEs, in form of inter-industry spillovers, could play in both direct and indirect ways. Measuring only the direct ones tends to underestimate the importance of industrial linkages and lead to overemphasis on the role of linkage effects.

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Pattarakorn Tantratananuwat is a graduate student in Economics, at Thammasat University, Thailand. Currently, he is the only student, in Master's degree class, who partially attend the coursework for Ph.D. In undergraduate's class, he was the only student who have practically graduated in 3 years. Regarding his achievement, he was awarded the first prize in competitions of derivative as well as insurance in Young Financial Star Competition (YFS), which is one of the biggest financial competition in Thailand. During attending graduate course, he has been temporary case team assistance for Bain & Company and Boston Consulting Group (BCG).

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