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Foreign Direct Investment and Technology Spillover: A Cross-Industry Analysis of Thai Manufacturing

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Summary. — This paper examines technology spillover from foreign direct investment (FDI) based on a cross-industry analysis of Thai manufacturing. The analysis is built around the hypothesis by Bhagwati that technology spillover is conditioned by the nature of the trade policy regime. The result, based on a two-equation model that allows for the two-way link between the foreign presence and productivity of locally owned industries, provides support for the hypothesis. A key policy implication is that liberalizing the foreign investment regime has to go hand in hand with liberalizing the trade policy regime to maximize gains from FDI technology spillover.

Key words — technology spillover, Thailand, FDI

1. IMPORTANCE OF THE ISSUE

Foreign direct investment (FDI) has been widely recognized as a growth-enhancing factor in investment receiving (host) countries. FDI not only brings in capital but also introduces advanced technology that can enhance the technological capability of the host country firms, thereby generating long-term and sustainable economic growth. More importantly, the technological benefit is not limited to locally affiliated firms but can also spread to non-affiliated ones. The latter benefit is usually referred to as technology spillover.

The expectation of gaining from technology spillover persuades many developing countries to offer various incentives in order to attract FDI. However, the results of empirical research to test the validity of technology spillover are far from conclusive. Positive technology spillover from FDI has only been found in some countries. [1] Overall, the findings seem to suggest technology spillover is not automatic, but depends on both country-specific factors and policy environment.

One such important factor is the nature of the trade policy regime. Starting with the pioneering paper by Bhagwati (1973), a sizable theoretical literature has attempted to explain how the restrictiveness (openness) of the trade policy regime conditions the gains to host countries from FDI (Bhagwati, 1978, 1985, 1994; Brecher & Diaz-Alejandro, 1977; Brecher & Findlay, 1983). A key hypothesis arising from this literature (which is referred to as the "Bhagwati hypothesis") is that technology spillover is likely to be far less or even negative under an import substitution (IS) regime, compared with a policy regime geared to export promotion (EP).

The only published empirical study which has explicitly tested the "Bhagwati hypothesis" in analyzing spillover effects of FDI is by Kokko, Zejan, and Tansini (2001). This study focuses on technology spillover conditioned by the country's trade policy regime, based on Uruguayan firm-level inter-industry analysis. In

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the study, the year 1973 where Uruguay embarked on trade liberalization reform is used as a benchmark in separating EP FDI from IS FDI. Foreign firms set up before 1973 are classified as IS firms and those set up after 1973 are classified as EP firms. The findings support the "Bhagwati hypothesis." There are, however, two caveats with this study. Firstly, the classification of EP and IS FDI using 1973 as the base year is problematic because the liberalization reforms implemented in that year were partial and some industries continued to remain under heavy protection (Favaro & Spiller, 1991). Moreover, the analysis suffers from a failure to address the possible simultaneity involved in the relationship between productivity of local firms and the foreign presence. The positive relationship between the foreign presence and productivity of local firms uncovered by the single-equation model might simply reflect the fact that foreign investment gravitates toward more productive industries rather than representing any technology spillover from FDI (Aitken & Harrison, 1999).

This paper aims to examine the role of the trade policy regime in explaining inter-industry differences in technology spillover from FDI in Thai manufacturing. It uses two alternative measures to proxy the nature of trade policy in an industry; the nominal rate of protection (*NRP*) and the effective rate of protection (*ERP*). In addition, the potential simultaneity problem is explicitly rectified by using a simultaneous-equation approach focusing on technology spillover and FDI determinants. Even though these are two separate international aspects of FDI, it is necessary to bring them together to rectify the simultaneity problem. The results will provide alternative explanations for the magnitude of FDI technology spillover as well as policy guidance on how to maximize the positive technology benefit of the foreign presence.

Thai manufacturing is a good laboratory for testing the issue for two reasons. First, although Thailand has been a large FDI recipient throughout the past three decades, technology spillover has not been quantitatively examined. Secondly, FDI inflows in Thai manufacturing have been well dispersed across IS and EP industries.

The remainder of this paper is structured as follows. Section 2 provides the relative importance of foreign firms and an overview of policy shifts in Thai manufacturing. The theoretical framework of the study is presented in Section 3. Section 4 presents the model, followed by a discussion of the data and the econometric method in Sections 5 and 6, respectively. The results are presented and discussed in Section 7. The concluding section presents key inferences and policy implications.

2. FOREIGN PRESENCE IN THAI MANUFACTURING

Data from the Industrial Census 1997 (data for 1996) are used to reveal the relative importance of foreign plants in Thai manufacturing (Table 1). The manufacturing sector in Table 1 is disaggregated into the three-digit ISIC industry level to highlight the relationship between some industrial characteristics and the nature of the foreign presence.

Three key inferences can be drawn from Table 1. Firstly, foreign firms play a vital role in Thai manufacturing. Almost 50% of gross output was manufactured by foreign plants, accounting for 48.3% of total manufacturing value added. Measured in terms of exports, the level of foreign presence was even higher than gross output and value added. Foreign plants accounted for 58.9% of manufacturing exports. Hence, foreign plants tend to be more export oriented than local ones. Nonetheless, in terms of employment share, foreign presence was less important with foreign plants accounting for only 35% of manufacturing employment. Their relatively lesser importance in terms of employment reflects the capital-intense nature of foreign firms widely observed in many developing countries.

Secondly, an output share of foreign plants to total industry (covering both foreign and local plants) is relatively large in electrical machinery, glass products, professional and scientific equipment, transport equipment, and beverages, with an output share accounting for more than 70% of total industry. The share of foreign plants measured in terms of employment, export, and value added to some extent provides a similar pattern. In these industries, production technology *per se* seems to be a proprietary asset and is dominated by a handful of multinational firms. This is in contrast to industries like ceramic products, footwear, furniture and woods products, toys, processed foods, and leather products where production technology is relatively stable and widely available. The output share of foreign plants in the latter industries ranges from 5.5% to 35%.

Table 1. *Measures of foreign presence and industrial characteristics of Thai manufacturing*

Description	Foreign presence[a] (% to total industry)				*ERP*[b] (%)	Market concentration[a] (%)
	Output	Employment	Export	Value added		
Electrical machinery	85.0	67.4	88.1	82.3	8.0	56.5
Glass and products	76.2	49.2	72.2	72.5	14.6	65.5
Professional and scientific equipment	73.4	61.5	90.9	80.6	17.8	71.4
Transport equipment	71.3	39.8	86.4	66.4	27.1	54.8
Beverages	70.5	85.6	44.1	72.6	3.5	75.8
Jewelry	64.6	42.6	60.8	56.7	−3.1	29.1
Other chemicals	61.2	36.0	59.9	53.0	8.9	57.8
Machinery, except electrical	58.6	41.5	74.6	57.2	10.9	64.8
Textiles	58.4	43.0	66.4	64.3	15.9	55.0
Rubber products	55.4	37.4	48.0	53.9	24.2	48.1
Fabricated metal products	55.2	34.9	77.5	60.9	19.3	53.0
Paper and products	53.3	23.6	61.2	48.2	35.9	57.2
Petroleum refineries	49.2	59.6	50.2	37.2	9.0	96.3
Industrial chemicals	42.8	49.7	64.2	42.5	0.1	50.0
Iron and steel	42.2	32.2	52.1	48.1	5.5	49.5
Plastic products	40.4	28.0	51.5	35.8	13.1	15.5
Wearing apparel, except footwear	35.5	18.5	44.1	32.7	51.4	17.7
Leather products	35.2	24.4	53.5	47.8	20.0	53.3
Furniture, except metal	34.1	15.5	47.7	29.0	20.7	16.2
Food products	30.8	21.5	37.3	29.2	13.1	40.7
Toys	23.9	18.7	36.1	31.1	17.8	36.2
Wood products, except furniture	20.1	8.3	28.1	17.5	13.1	44.3
Footwear, except rubber or plastic	18.4	24.7	47.4	30.7	6.0	34.3
Ceramic products	5.5	14.5	32.9	32.5	53.7	75.1
Tobacco	4.6	8.9	18.4	2.8	73.3	97.9
Manufacturing	48.3	34.9	58.9	48.3	16.0	54.1

Note: *ERP* is effective rate of protection. Market concentration is referred to as the sum of the top five firms' market share. For a full discussion of variable construction, see Section 4.
[a] Data compiled from the Industry Census 1997 (Data for 1996), conducted by NSO.
[b] Data compiled from Athukorala *et al.* (2004).

Thirdly, foreign plants are likely to be located in a highly protected industry. The average *ERP* [2] of industries whose output shares of foreign plants are greater than 50% is 15.3%. The exception in these industries would be electrical machinery, which is presumably dominated by labor-intensive assembled electronics and electrical appliances. On the other hand, regarding the industries where the share of foreign plants is less than 50%, average *ERP* tends to be lower at around 10.8%. [3] In addition, the output share of foreign plants is likely to be associated with the degree of market concentration.

Involvement of foreign plants in the manufacturing sector was predominately in import-substituting industries such as textiles, automobiles, and chemicals up to about the late 1970s (Akira, 1989). From then on, it was directed to more export-oriented activities. To begin with, export-oriented foreign firms entered light manufacturing industries such as clothing, footwear, and toys. More recently, labor-intensive assembly activities in electronics and electrical goods industries have been the main attraction for foreign investors (Kohpaiboon, 2005).

Such involvement has closely mirrored the shift in the trade policy regime. Thailand began its first national economic development plan in 1961 with an IS regime to promote industrialization. Tariffs were the major instrument used to influence the country's development path. The role of tariffs to promote the domestic industry effectively began in 1974 with the imposition of an escalating tariff structure, where the tariff rate ascended from raw materials to finished products. These changes increasingly favored the production of finished products, particularly consumer products. In 1975, the range of the effective rate of protection (*ERP*) in the Thai manufacturing sector was between −36% and 350% (Akrasanee & Ajanant, 1986). In 1982, the variation widened from −25.2% to 1693.4% (Chunanantatham, Tambunlertchai, & Mongkolsmai, 1984). Several industries, such as textiles, tires, furniture, automobiles, and leather products, had an extremely high *ERP*. There was also a high degree of variation in *ERP* across industries. This tariff structure remained virtually unchanged until the late 1980s, even though in 1974 the government announced a change in development strategy to an EP regime.

Significant tariff reductions commenced in 1988, starting with electrical and electronic goods as well as with the inputs into these products. Comprehensive packages of tariff reform were implemented in 1995 and 1997. It involved tariff reduction and rationalization. Maximum tariffs were reduced from 100% in the early 1990s to 30%. By the end of the 1990s, the tariff bands were reduced from 39 to 6 tariff rates (0%, 1%, 5%, 10%, 20%, and 30%). The two low rates (0% and 1%) were for raw materials and the two top rates (20% and 30%) for finished products with the two middle rates for intermediate goods. In addition, tariff restructuring has received renewed emphasis as an essential part of the overall economic reforms aimed at strengthening efficiency and competitiveness over the past two years. The Thai government introduced another effort to lower tariff rates, commencing in June 2003 (implemented in October 2003), followed by a four-year period of tariff reduction from 2004 to 2008. There are around 900 items involved in the second round of tariff reductions, covering a wide range of manufacturing products. The tariff reduction in this round is mainly on intermediate products, thereby maintaining the escalating tariff structure. The magnitude of tariff reduction is moderate, within the range of 0–8.9% (Athukorala, Jongwanich, & Kohpaiboon, 2004).

As a result, average tariffs declined markedly from 30.2% in 1990 to 21.3% in 1995 and further to 11% in 2005. The dispersion of *ERP* also narrowed over the periods across industries. In 2003, the *ERP* range reduced from −27.1% to 142% (Athukorala *et al.*, 2004). [4] The changes in the tariff structure would have significantly improved the incentive to attract FDI to industries where Thailand has a comparative advantage in international production.

3. ANALYTICAL FRAMEWORK

Technology spillover from FDI is said to take place when the presence of a foreign firm generates productivity or efficiency benefits for the host country's local non-affiliated firms (Blomström & Kokko, 1998). As mentioned, technology spillover from FDI is not automatic but rather conditioned on the nature of the trade policy regime across industries. A theoretical framework for examining the effect of the trade policy regime on the gains from FDI in a given host country was first presented by Bhagwati (1973) as an extension to his theory of immiserizing growth. It was further developed by Bhagwati (1985, 1994), Brecher and Diaz-Alejandro (1977), and Brecher and Findlay (1983). A key hypothesis arising from this literature is that technology spillover tends to be smaller, or possibly even negative, under a restrictive, IS regime compared with a liberalizing, EP regime.

To illustrate how technology spillover takes place as well as how the trade policy regime across industries can alter the magnitude of these spillovers as suggested by Bhagwati (1973), we use the theoretical model developed by Wang and Blomström (1992). In the model, there are two firms, namely an affiliate of a multinational enterprise (MNE) and a local non-affiliated firm (henceforth referred to as the "foreign" and "local" firms, respectively), producing differentiated but substitutable products for the host country market. Technology spillover is an outcome of interaction of these two firms. On the one hand, the entry of a foreign firm is always associated with some amount of proprietary technology from the parent company so as to offset the potential disadvantage against the local firm possessing superior knowledge of the availability of factor inputs, business practices, and/or consumer preferences in the host country. In addition, advanced technology would help the foreign firm to gain market share in the host country. However transferring technology from MNE's headquarter to its affiliates is costly. The more the advanced level of technology transferred, the larger the dollar costs associated with the transfer. Because of the presence of cost and benefit, the foreign firm has to decide on the effort of undertaking technology transferred from its headquarter to maximize its net benefit. Such effort would depend on the local firm's response to the presence of the foreign firm. In a situation where 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. As a result, it will need to keep undertaking technology transfer activities in the following period in order to maintain the advantage or even to just survive in the host country environment. In contrast, a situation where the local firm is less responsive in attempting to learn the associated technology provides relatively less incentive for the foreign firm to continue to actively undertake technology transfers from its parent company.

On the other hand, 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 associated with the foreign firm has certain public good qualities, which cannot be fully internalized, thus the localization of the foreign firm could potentially generate positive externality in terms of technological benefit to the local firm. Since the market success of each firm depends on the level of technology it employs, this encourages the local firm to learn the associated superior technology. Nevertheless, the effort of learning and adapting the associated technology is associated with the dollar amount of cost so that the local firm has to decide its effort to learn associated advanced technology. Similar to the foreign firm, the learning effort of the local firm also depends on the behavior of the foreign firm.

To incorporate the "Bhagwati hypothesis," the model discussed above is modified by hypothesizing that the trade policy regime influences the cost effectiveness in the learning activities of the local firm. That is, every effort to enhance the technological capability of the local firm is more costly in any industry where the trade regime is more restrictive. This is because much of the FDI flowing to an industry with high trade restrictions often enters relatively capital- and skill-intensive products where output is mainly supplied for a highly protected domestic market. Although the production technology associated with FDI is typically older and less advanced than used in the MNE's home country, it is often relatively capital- and skill-intensive compared to those employed by the local firm. In this environment, it is more difficult for the local firm to learn the advanced technology. Instead, the highly protected domestic market might encourage the local firm to produce products not directly competitive with those being produced by the foreign affiliate and to enjoy economic rents induced by the regime. Kokko (1994) refers to this as a situation where the foreign affiliate in such an industry may operate in "enclaves" in isolation from the local firm.

In contrast, in the context of a liberal trade regime, technology spillover from a foreign presence is likely to generate a more productivity enhancing effect. This is because the main incentives for FDI in a given host country are the relatively low labor costs and/or availability of raw materials. FDI inflows under an EP trade regime can be expected to employ technologies more in line with the host country's comparative advantage. A higher level of policy neutrality creates a higher likelihood for MNEs to become involved with the host country's production to serve their strategy for maintaining a competitive position in international markets. With this motivation, the associated advanced technology will be cutting edge and will make use of the existing resource endowments in the host country (Moran, 2001). Under these circumstances, it is easier for the demonstration effect of foreign involvement in the host country to operate. Global competition makes all economic agents actively seek technological innovation to improve efficiency.

4. THE MODEL

(a) *Productivity determinants*

To examine factors determining industry productivity, we start with the Cobb–Douglas production function of the locally owned industry, specified as [5]

$$Y_j^d = A_j^d (L_j^d)^{\alpha_1} (K_j^d)^{\alpha_2} e^{\varepsilon_j}, \quad (1)$$

where Y_j^d represents output (value added); L_j^d, K_j^d, and A_j^d denote the number of workers, capital stock, and total factor productivity (*TFP*); ε_j is a random disturbance term; the subscript j denotes the locally owned jth industry. When expressed in per capita terms and converted into log-linear form, Eqn. (1) becomes [6]:

Dividing Eqn. (1) by L_j^d,

$$Y_j^d/L_j^d = A_j^d\left[(K_j^d)^{\alpha_2}/(L_j^d)^{1-\alpha_1}\right]e^{\varepsilon_j}$$
$$= A_j^d\left[(K_j^d)/(L_j^d)\right]^{1-\alpha_1}[K_j^d]^{(\alpha_1+\alpha_2-1)}e^{\varepsilon_j}. \quad (2)$$

Take natural logarithm in Eqn. (2)

$$\ln(Y_j^d/L_j^d) = \ln A_j^d + \beta_1 \ln(K_j^d/L_j^d) + \beta_2 \ln K_j^d + \varepsilon_j, \quad (3)$$
$$LP_j^d = TFP_j^d + \beta_1(k_j^d/l_j^d) + \beta_2 k_j^d + \varepsilon_j,$$

where LP_j^d is the value added per worker or labor productivity of the locally owned *j*th industry and TFP_j^d represents $\ln A_j^d$. The small letter symbols represent the natural log form. That is, (k_j^d/l_j^d) and k_j^d stand for $\ln(K_j^d/L_j^d)$ and $\ln K_j^d$, respectively. The capital stock (k_j^d) is included on an additional variable in order to relax the constant-return-to-scale assumption.

As discussed in the previous section, the level of technology represented by *TFP* is influenced by the level of foreign presence and the nature of the trade policy regime in the host country. To capture the effect of the trade policy regime, an interaction variable of foreign presence (*FOR*) and trade policy proxy (*TP*) is added to the model. Moreover, as argued by a number of empirical studies (e.g., Edwards, 1998; Sachs & Warner, 1995), *TP* itself could also have an impact on *TFP*. Hence,

$$TFP_j^d = \beta_0 + \beta_3 FOR_j + \beta_4 FOR_j * TP_j + \beta_5 TP_j, \quad (4)$$

where FOR_j represents foreign presence and TP_j is a proxy of trade policy in the *j*th industry.

By substituting Eqn. (4) in (3), we obtain

$$LP_j^d = \beta_0 + \beta_1(k_j^d/l_j^d) + \beta_2 k_j^d + \beta_3 FOR_j + \beta_4 FOR_j * TP_j + \beta_5 TP_j + \gamma X_j + \varepsilon_j, \quad (5)$$

where X_j is a set (matrix) of explanatory variables containing industry-specific factors of the *j*th industry.

Note that the specification in Eqn. (5) does not imply that all industries must have the same capital–labor ratio, that is, the identical technology. Rather we draw an inference of the impact of capital–labor ratio on the industry's productivity across industries. These industries must exhibit a significant level of variation in their capital–labor ratio from each other. Otherwise, the coefficient corresponding to the capital–labor ratio variable is not likely to be obtained. This functional form is widely used in previous studies using industry-level data (e.g., Blomström & Persson, 1983; Kokko, 1994).

The impact of FDI on the industry's productivity is given by the partial derivative of LP^d with respect to *FOR*:

$$\frac{\partial LP_j^d}{\partial FOR_j} = \beta_3 + \beta_4 TP_j. \quad (6)$$

To test the role of the trade policy regime, that is, "Bhagwati hypothesis," the statistical significance of β_4 is examined. Under the "Bhagwati hypothesis," the sign of β_4 is expected to be negative. That is, technology spillover from FDI to the industry's productivity will be a decreasing function of the level of trade restrictiveness. The sign of β_3 is ambiguous, depending on the nature of the trade policy bias over the whole manufacturing sector.

Foreign presence (*FOR*) is measured by the output share of foreign firms to total industry. In some previous empirical studies, employment or capital shares have been used to measure the foreign presence. Expressing the foreign presence as an employment share tends to underestimate the actual role of foreign affiliates because MNE affiliates tend to be more capital intensive than locally non-affiliated firms. [7] On the other hand, the capital share can easily be distorted by the presence of foreign ownership restrictions. Such a restriction was in effect in Thailand during the study period (Kohpaiboon, 2005). Hence, the output share is the preferred proxy.

The trade policy regime (*TP*) is proxied using two alternative measures, namely nominal rate of protection (*NRP*) and effective rate of protection (*ERP*). These two measures have been used in previous empirical analysis. However, there is no consensus amongst economists as to choice of one over the other. *ERP* is obviously theoretically superior to *NRP* since it measures "true" net pulls on resource allocation and true proportional inflation of payments to factors by the overall tariff structure (Corden, 1966). On the other hand, *NRP* is presumably a more visible indicator of protection to interest groups, which generally tend to demand changes in protection on nominal rates on their outputs rather than seeking changes in the rates of tariffs on inputs (Cheh, 1974).

In addition, as guided by the theory and previous empirical works on the determinants of inter-industry changes in productivity, three additional explanatory variables are used. Firstly, this study takes into account the role of labor quality (QL) in determining productivity. A high quality of labor is likely to contribute to an increase in value added per worker. The ratio of supervisory and management workers to total employment is used here to proxy the quality of labor. The rationale of this proxy regards supervisory and management workers as skilled labor. Thus, the higher the ratio, the higher the labor quality. A positive sign to the associated coefficient is expected.

Secondly, the technology gap ($TECH$) between foreign and local firms is another key determinant of the degree of technology spillover. $TECH$ is proxied by the ratio of average value added per worker between foreign and local firms net of capital intensity and firm size. While the ratio of average labor productivity of foreign firms to that of locally owned ones has been widely used in previous studies, this measure suffers from the possibility that the larger labor productivity is due to the greater degree of capital intensities and/or the larger scale of production rather than differences in technologies, that is, the ability to transform inputs into outputs. Differences in capital intensity and/or sales could be due to several factors that might not be directly related to technological capability. For example, foreign and local firms would face different relative costs of labor and capital because of their different abilities to access factor inputs. This would differ their capital intensities from one another and not necessarily imply different technological capabilities. Moreover, a firm with a longer period of operation in a given country could well be larger in size, compared to a new firm even if they have the same level of technology. Therefore, to guard against these possibilities, the effects of capital intensity as well as size would be excluded when measuring the technology gap. Using the plant-level data, the difference in labor productivity between domestic and foreign establishments is estimated for each industry, after accounting for capital intensities and scale of production based on the following equation [8]:

$$LP_{ij} = a_{ij} + b_{1ij}(k/l)_{ij} + b_{2ij}sale_{ij} + b_{3j}foreign, \quad (7)$$

where $sale_{ij}$ is the (log) value of total sales of the ith firm in the jth industry and $foreign$ is a dummy variable, which equals to 0 if the share of foreign ownership is zero and 1 otherwise.

According to Eqn. (7), the coefficient b_{3j} is a measure of the difference in technology after taking into account capital intensity and firm size. The larger the coefficient b_{3j}, the more superior is the technology gap of foreign firms compared to the local ones. The lower the technological gap between the foreign affiliate and a local firm in a given industry, the easier the latter will be able to emulate the technology brought in by the former. For this reason, a negative relationship is hypothesized between $TECH$ and LP^d across industries.

Thirdly, market concentration (CON) is included as an explanatory variable because two industries with the same technical efficiency may show a different value added per worker because of different domestic market concentrations. In addition as argued by Hall (1988), the impact of any possible exogenous factors on industry productivity would be conditioned by the degree of market concentration. Hence, the market concentration is needed to be incorporated into the model. Two widely used proxies are chosen for market concentration, the sum of market share of the five largest firms ($CR5$), and the Herfindahl–Hirshman index of concentration (HHI). The formulae to calculate both proxies for market concentration are in Eqns. (8) and (9), respectively. Hence, a positive sign is expected for the corresponding coefficient:

$$CR5_j = \frac{\sum_{i=1}^{5} s_{ij}}{\sum_{i=1}^{n} s_{ij}}, \quad (8)$$

$$HHI_j = \sum_i \left(\frac{s_{ij}}{\sum s_{ij}} \right)^2, \quad (9)$$

where s_{ij} is total sales of the ith firm in the jth industry.

(b) *Foreign presence*

In order to redress the problem of simultaneity involved in the relationship between FOR and LP^d, Eqn. (5) is estimated together with a separate equation to explain the FDI determinants at industry level. The specification of the second equation is discussed below before presenting the two-equation model. In addition to a potential relationship with LP^d, FOR is a function of market size, tariff barriers, and labor quality. These three variables have been widely used in previous empirical studies on FDI determinants.

TP is included as an explanatory variable to examine the validity of the "tariff hopping" hypothesis that protective tariff barriers stimulate IS FDI. This hypothesis has been supported by various empirical studies (e.g., Jun & Singh, 1997; Lim, 2001). The size of the domestic market would be one of the relevant factors for MNEs when deciding modes of entry, that is, either producing at and exporting from the home country, or locating and producing within the host country. The size of the domestic market (*MSIZE*) is measured by the sum of gross output and (net) import at the four-digit ISIC level, averaging over the period 1986–94. MNEs are more likely to establish affiliates in large domestic markets.

In a small open economy like Thailand, *TP* or *MSIZE* alone might not be significant enough to attract FDI. It would be more appropriate to add the interaction term to capture the impact of both *TP* and *MSIZE*. The interaction between *TP* and *MSIZE* implies the impact of *TP* in stimulating FDI, which is likely to depend on *MSIZE*. At a given level of tariff protection, a larger market size enhances the stimulating impact of tariff barriers on the foreign presence. Similarly, in Thailand, market size *per se* might not be large enough to attract a MNE to locate its affiliate and to substitute international trade for investment. In other words, the impact of market size on FDI determinants depends positively on tariff barriers. Hence, the coefficient of interaction term is expected to be positive while the coefficients associated with *TP* and *MSIZE* could be either positive or negative. Even though the coefficients associated with both these variables turn out to be negative, it is not possible to conclude tariff barriers or market size exhibit a negative relationship with the foreign presence, as it also depends on the interaction effect.

Finally, the standard hypothesis that quality of labor will encourage "efficiency-seeking" FDI inflows is incorporated in the analysis by taking the variable labor quality (QL) into account. Some foreign investors locate entrepreneurial activities across countries in order to access cheaper and/or better quality raw material and/or labor to enhance productivity. This hypothesis is in evidence to explain the behavior of FDI inflows in the late 1980s, especially in developing countries like Thailand and Malaysia.

(c) *The model*

Based on the above discussion, the estimating equations are specified as follows:

$$LP_j^d = \beta_0 + \beta_1(k_j^d/l_j^d) + \beta_2 k_j^d + \beta_3 FOR_j + \beta_4 FOR_j * TP_j + \beta_5 TP_j + \beta_6 CON_j + \beta_7 TECH_j + \beta_8 QL_j + \varepsilon_j, \quad (10)$$

$$FOR_j = \gamma_0 + \gamma_1 TP_j + \gamma_2 MSIZE_j + \gamma_3 TP_j * MSIZE_j + \gamma_4 LP_j^d + \gamma_5 QL_j + \mu_j, \quad (11)$$

where LP_j^d is the labor productivity of locally owned *j*th industry (in log), (k_j^d/l_j^d) is the capital–labor ratio of locally owned *j*th industry (in log), k_j^d is the capital stocks of locally owned firm *j*th industry (in log), FOR_j is the foreign presence proxied by the share of foreign output to the *j*th industry (in log), TP_j is the trade policy regime proxied alternatively by (in log) [(1) $NRP_j =$ nominal rate of protection of the *j*th industry, (2) $ERP_j =$ effective rate of protection of the *j*th industry], CON_j is the market concentration index of the *j*th industry proxied alternatively by (in log) [(1) $CR5_j =$ sum of market share of the five largest firms in the *j*th industry, (2) $HHI_j =$ Herfindahl–Hirshman index of concentration of the *j*th industry], $TECH_j$ is the technology gap between local and foreign firms in the *j*th industry proxied by estimation using Eqn. (7), QL_j is the labor quality of the *j*th industry proxied by the ratio of supervisory and management workers to total industry employment (in log), $MSIZE_j$ is the market size of the *j*th industry measured by the sum of gross output and (net) import at the four-digit ISIC level (in log).

5. DATA DESCRIPTION

Data for the study are compiled from unpublished returns to the Industrial Census 1997 (data for 1996) conducted by the National Statistics Office (NSO). A well-known limitation of the cross-sectional data set with each industry representing a single data point is that they make it difficult to control for unobserved industry specific differences. Long-term averages tend to ignore changes that may have occurred over time in the same country. These limitations can be avoided by using the panel data set compiled by pooling cross-industry and time-series data. Particularly, in the nature of technology spillover that involves a time-consuming process, panel data are more appropriate. Unfortunately, given the nature of data availability in this case, this preferred data choice is not possible. Data are available electronically for all years from 1993 to 1999. The year 1996 is chosen for the study because 1997–99 data are not "normal" years, compared to the 1996 ones. The firm coverage of the survey for 1993–95 is rather incomplete. [9]

The census covers 32,489 plants, belonging to 126 four-digit industries of TSIC. Of these, 23,677 plants responded to the questionnaire. The census was cleaned up by firstly deleting plants which had not responded to one or more of the key questions and which had provided seemingly unrealistic information such as the negative value added, no report of value of raw materials and capital stocks, or the initial capital stock of less than 1,500 baht. And then, 21 industries that are either to serve niches in the domestic market (e.g., processing of nuclear fuel, manufacture of weapons and ammunition), in the service sector (e.g., publishing of recorded media, building and repairing of ships) or explicitly preserved for local enterprises (e.g., manufacture of ovens, furnaces and furnace burners, manufacture of coke oven products, manufacture of bicycles and invalid carriages, etc.) are excluded. Plants with employment of less than 10 workers are also dropped.

As has been identified by Ramstetter (2004), there are some duplicated records in the survey return, presumably because plants belonging to the same firm filled the questionnaire using the same records. The procedure followed in dealing with this problem was to treat the records that report the same value of the nine key variables of interest in this study, [10] are counted as one record. There are 4,900 such cases which reduced to 2,064 as a result of this screening. Thus, the final sample dropped to 15,624 plants (1,510 foreign-owned and 14,114 domestic-owned plants) across 105 industries. [11] These plants accounted for 61.5% of Thailand's manufacturing value added and 36.5% of manufacturing labor force in 1996.

To estimate the foreign presence, the ratio of sales of foreign firms to total sales (local and foreign) is measured. All plants with FDI (regardless of the magnitude of the foreign share in capital stock) are considered to be foreign firms for the identification of local firms. LP^d, (k^d/l^d), and k^d are the result of the sum of locally owned plants within the jth industry. 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. *CR5*, *HHI*, and *TECH* are constructed from data for all plants as from the formulae discussed above. For measuring labor quality, the supervisory and management workers are defined as employees not directly engaged in production or other related activities. The actual number of supervisors and management workers are not available in the census. So the number of non-production workers reported would also include clerical and administrative staff. Nevertheless, the number of non-production workers could still to some extent be a reasonable proxy of that of the available supervisors because the number of support staff is likely to go hand in hand with that of supervisors and management workers.

Data on *ERP* and *NRP* are from Athukorala *et al.* (2004). They reflect the protection structure in 1997. Even though the *NRP* and *ERP* estimates mainly capture the only tariff protection, this is not a major limitation because there are not many quantitative restrictions (QRs) and subsidies in Thai manufacturing. In addition, the *ERP* series used is the weighted average of import-competing and export-oriented *ERP*, [12] so that the impact of various tariff rebate programs is incorporated in *ERP* estimates. Data on the gross output, export, and import on four-digit ISIC industries are obtained from United Nations Industrial Development Organization (UNIDO) series held at the International Economic Data Bank of the Australian National University. Tables 2 and 3 provide a statistical summary as well as a correlation matrix of all relevant variables in this analysis, repectively.

6. ECONOMETRIC PROCEDURE

Initially the equations are estimated using the ordinary least squares (OLS) method while paying attention to the possible presence of outliers. Due to the nature of cross-sectional data, it is likely that outliers could impact on and mislead the estimated parameters and therefore a careful treatment of outliers is needed. Cook's distance [13] is used to identify suspected outliers. To accommodate the outliers, intercept dummies are introduced and estimated to test both changes in estimated parameters and significance of the interested dummy. Having decided upon the basic form of Eqns. (10) and (11), which contain current endogenous variables as explanatory variables, they are re-estimated using the two-stage least squares (2SLS) method.

Unbiasedness and consistency of OLS estimates rest on the assumption that the

Table 2. *A statistical summary of the key variables*

	Unit	Mean	SD	Min	Max
LP_j^d	(Log) thousand baht/worker	5.34	0.77	3.87	9.04
(k_j^d/l_j^d)	(Log) thousand baht/worker	5.86	0.94	3.93	10.69
k_j^d	(Log) thousand baht	14.36	1.55	10.65	18.45
FOR_j	(Log) proportion	0.37	0.20	0.00	0.69
NRP_j	(Log) proportion	0.14	0.07	0	0.47
ERP_j	(Log) proportion	0.13	0.19	−1.28	0.69
$CR5_j$	(Log) proportion	0.42	0.13	0.14	0.68
QL_j	(Log) proportion	0.22	0.10	0.07	0.54
$TECH_j$	None	−0.12	0.46	−1.42	1.31
$MSIZE_j$	(Log) $million	6.23	1.67	1.39	8.94
HHI_j	Proportion squared	0.12	0.11	0.01	0.63

Notes: Mean = simple average; SD = standard deviation; Min = minimum; and Max = maximum.
Estimates of LP_j^d, (k_j^d/l_j^d), and k_j^d are the logarithmic transformation of their value. The other variables are converted into logarithmic form as $\log(1 + x)$ where x is the variable.
Source: Author's computations are based on data sources described in the text.

Table 3. *Correlation matrix of the variables*

	LP_j^d	$(k/l)_j^d$	k_j^d	FOR_j	NRP_j	ERP_j	$CR5_j$	HHI_j	QL_j	$TECH_j$
LP_j^d	1									
(k_j^d/l_j^d)	0.65	1								
k_j^d	0.47	0.59	1							
FOR_j	−0.23	−0.11	−0.33	1						
NRP_j	−0.21	−0.27	−0.01	−0.07	1					
ERP_j	−0.09	−0.11	0.01	−0.07	0.55	1				
$CR5_j$	0.16	0.23	−0.34	0.35	−0.04	0.05	1			
HHI_j	0.29	0.31	−0.08	0.21	0.07	0.11	0.80	1		
QL_j	0.11	0.21	−0.05	0.08	−0.09	0.04	0.29	0.19	1	
$TECH_j$	−0.33	0.04	0.01	−0.15	−0.06	−0.04	−0.20	−0.27	0.09	1
$MSIZE_j$	0.19	0.26	0.18	−0.09	−0.08	0.02	−0.01	−0.02	0.29	0.09

Source: Author's computations are based on data sources described in the text.

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 makes the use of OLS inappropriate. The alternative estimators devised to be used in this situation fall into two main categories: 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, are superior to the single-equation methods in terms of efficiency of the estimates. However, in 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, causing 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 performs 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, p. 389). Moreover, 2SLS and 3SLS estimates are equivalent asymptotically (Wooldridge, 2002, p. 199).

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 whose part of the variation is due to the disturbance.

7. RESULTS

The regression results relating to determinants of productivity are reported in Table 4. All equations in Table 4 included intercept dummies for four observations (industries), which were found to be outliers in terms of the Cook's Distance test. [14] Eqn. (4.1) represents the OLS estimating results, where *FOR*, *TP* proxied by *ERP*, and their interaction term are included. The estimated equation passes the *F*-test for overall statistical significance at the 1% level and performs very well by the standard diagnostic tests. Despite obtaining theoretical expected sign, these

Table 4. *Determinants of labor productivity in locally owned industries (LP_j^d): Regression results with alternative measures of trade policy regime*

	TP = ERP				*TP = NRP*	
	(4.1) OLS	(4.2) OLS	(4.3) OLS	(4.4) 2SLS	(4.5) OLS	(4.6) 2SLS
Intercept	3.84	3.88	3.81	4.25	3.97	4.19
	(4.23)*	(4.31)*	(4.24)*	(3.03)*	(4.44)*	(3.55)*
k_j^d/l_j^d	0.49	0.49	0.49	0.47	0.47	0.47
	(6.08)*	(6.13)*	(6.15)*	(5.30)*	(5.84)*	(5.53)*
k_j^d	0.10	0.09	0.10	0.09	0.10	0.10
	(1.91)**	(1.90)**	(1.92)**	(1.66)**	(2.03)**	(1.82)**
FOR_j	−0.81	−0.91	−0.74	−1.14	−0.46	−0.68
	(−2.23)*	(3.44)*	(−2.55)*	(−1.03)	(−1.27)***	(−0.78)
$FOR_j * TP_j$	−0.59		−1.03	−1.74	−2.92	−3.05
	(−0.35)		(−1.55)***	(−1.25)***	(−1.62)***	(−1.45)***
TP_j	−0.14	−0.26				
	(−0.33)	(−1.04)				
$TECH_j$	−0.52	−0.53	−0.51	−0.51	−0.51	−0.51
	(−4.54)*	(−4.82)*	(−4.60)*	(−4.45)*	(−4.62)*	(−4.56)*
$CR5_j$	0.83	0.83	0.82	1.07	0.81	0.91
	(1.62)***	(1.62)***	(1.60)***	(1.43)***	(1.61)***	(1.49)***
QL_j	−0.03	−0.003	−0.06	−0.08	−0.13	−0.14
	(0.06)	(−0.01)	(−0.11)	(−0.14)	(−0.25)	(−0.25)
Adj. R^2	0.63	0.63	0.63	0.61	0.64	0.63
F-statistics	15.5*	17.1*	17.2*	16.0*	17.5*	17.3*
# Observation	105	105	105	105	105	105
# Outliers	4	4	4	4	4	4
Diagnostic tests						
RESET	2.10	2.04	2.13	1.32	1.93	1.54
	($p = 0.15$)	($p = 0.15$)	($p = 0.14$)	($p = 0.25$)	($p = 0.17$)	($p = 0.22$)
JBN	5.27	5.46	5.16	3.27	6.40	5.25
	($p = 0.07$)	($p = 0.07$)	($p = 0.08$)	($p = 0.20$)	($p = 0.05$)	($p = 0.73$)
HET	0.69	0.64	0.71	0.15	0.84	0.17
	($p = 0.41$)	($p = 0.42$)	($p = 0.40$)	($p = 0.70$)	($p = 0.36$)	($p = 0.68$)
Overidentification				2.31		1.26
				($p = 0.29$)		($p = 0.32$)

Notes: Numbers in parentheses are *t*-statistics and *, **, and *** indicate the level of statistical significance at 1%, 5%, and 10%, respectively. *RESET* = Ramsey test for functional form misspecification (*F*-distribution); *JBN* = Jarque–Bera test for normality of the error term ($\chi^2(2)$); *HET* = White test for heteroscedasticity (*F*-distribution); Overidentification test is obtained as NR_{ε}^2 from the regression $\widehat{\varepsilon}$ on all instruments where $\widehat{\varepsilon}$ is the 2SLS residual and R_{ε}^2 is the associated *R*-squared (χ^2 distribution); and the instrument variables are *MSIZE* and *ERP* as well as their interaction with *TP*.
Source: Author's estimates are based on data series discussed in the text.

three key variables of interest are not significantly different from 0. This would be due to the presence of the multicollinearity problem that occurs among them. In the absence of a strong theoretical reason in favor of dropping one variable over the other, two alternative functional forms are estimated. On the one hand, the interaction term is dropped from Eqn. (4.1) and the equation is re-estimated as reported in Eqn. (4.2). On the other hand, Eqn. (4.3) is the OLS estimating result of Eqn. (4.1), from which *ERP* is dropped. The OLS estimating results of both equations perform equally well in terms of the overall fit and the standard diagnostic tests, especially the functional form test. Nevertheless, only the interaction term between *ERP* and *FOR* in Eqn. (4.3) is statistically significant with the theoretically expected sign. Hence, the functional form in Eqn. (4.3) is the preferred choice. This function form is also applied when *TP* is proxied by *NRP* as in Eqn. (4.5).

The 2SLS estimates of Eqns. (4.3) and (4.5) are reported as Eqns. (4.4) and (4.6), respectively. Even though two alternative estimation methods provide remarkably similar results, the equations estimated by 2SLS are our preferred estimation. The reason is that there would be an endogeneity problem between the productivity of locally owned industry and the foreign presence.

Regression estimates turn out to be remarkably resilient to the use of the two alternative trade policy measures. As argued in Kohpaiboon (2005), there was a significant impact of various tax rebate schemes on the incentive structure during the study period, so the *ERP* estimates would be a better indicator to reflect the nature of the trade policy regime across industries. Hence, the following discussion focuses on the equation estimated using the 2SLS regression with *ERP* as the trade policy measure. The concentration indices, *CR5* and *HHI*, yield similar results. Based on the overall statistical significance (*F*-test), only the *CR5*-based estimates are reported. Most of the estimates except *FOR* and *QL* are significantly different from 0 with the theoretically expected signs.

Despite the mild statistical significance (i.e., the 10% level), the negative coefficient of $FOR * ERP$ fails to reject the "Bhagwati hypothesis" that industries with trade regimes characterized by greater outward orientation tend to yield more benefits in the form of technology spillover from foreign affiliates. The evidence that the coefficient of *FOR* is not statistically different from 0, points out that foreign presence could either negatively or positively affect the productivity of locally owned industry, depending on the nature of the trade policy regime, that is, *ERP* greater or less than zero. This finding is in line with previous studies that have examined the more aggregated data, for example, Balasubramanyam, Salisu, and Sapsford (1996), Athukorala and Chand (2000), and Kohpaiboon (2003). At the mean level of *ERP* (i.e., 16%), the foreign presence generates the net negative impact on the productivity of locally owned industry. A percentage increase in *FOR* reduces the labor productivity by 0.15%.

The coefficient of *TECH* is significantly different from 0 at the 1% level with the theoretically expected (negative) sign. This suggests that, given the level of foreign presence and degree of trade restrictiveness, a locally owned industry that exhibits laggard technology capability relative to a foreign firm tends to exhibit lower labor productivity.

For the impact of competition, the coefficient β_6 for *CR5* reaches a positive sign and is statistically different from 0. This suggests that a highly concentrated market structure significantly impacts on the value added per worker. The coefficient associated with *QL* is not statistically significant.

Table 5 presents the regression results relating to determinants of foreign presence in Thai manufacturing. All equations in Table 5 include intercept dummies for four observations (industries) which were found to be outliers in terms of the Cook's distance test. [15] Eqns. (5.1) and (5.3) represent the OLS results based on *ERP* and *NRP*, respectively, as a proxy of *TP*. While *MSIZE*, *TP* and their interaction are all in both equations and it is likely the estimates are affected by the multicollinearity problem, all estimated coefficients still obtain the theoretically expected sign and are statistically significant at the 10% level. As argued by Gujarati (1999, p. 327), the multicollinearity problem would be acceptable as long as most individual regression coefficients are statistically significant. In addition, if the objective of the study is to estimate a group of coefficients (e.g., the sum or difference of two coefficients) fairly accurately, this can be done even in the presence of multicollinearity. Hence, the functional form where three variables in the equations are incorporated is the preferable choice.

The equations pass the *F*-test for overall statistical significance at the 5% and perform well

Table 5. *Determinants of foreign presence in Thai manufacturing: Regression results with alternative measures of trade policy regime*

	TP = ERP		*TP = NRP*	
	(5.1) OLS	(5.2) 2SLS[1]	(5.3) OLS	(5.4) 2SLS[1]
Intercept	1.06	0.95	1.77	1.90
	(3.26)*	(2.00)**	(4.41)*	(2.74)*
LP_j	−0.05	−0.04	−0.07	−0.08
	(−1.73)**	(−0.89)	(−2.63)*	(−1.52)**
$MSIZE_j$	−0.03	−0.03	−0.08	−0.08
	(−1.60)***	(−1.63)**	(−2.28)*	(−2.24)*
TP_j	−0.76	−0.78	−2.86	−2.86
	(−1.23)***	(−1.25)***	(−2.15)**	(−2.15)**
$TP_j * MSIZE_j$	0.11	0.11	0.38	0.38
	(1.28)***	(1.27)***	(1.93)**	(1.92)**
QL_j	0.41	0.41	0.27	0.27
	(1.99)**	(1.98)**	(1.36)***	(1.37)***
Adj. R^2	0.07	0.08	0.11	0.11
F-statistics	2.00**	2.00**	2.56*	2.54*
# Observations	105	105	105	105
# Outliers	4	4	3	3
Diagnostic tests[2]				
RESET	2.53	2.03	0.03	1.46
	($p = 0.11$)	($p = 0.16$)	($p = 0.85$)	($p = 0.23$)
JBN	3.89	4.11	4.22	3.93
	($p = 0.14$)	($p = 0.13$)	($p = 0.12$)	($p = 0.14$)
HET	0.42	1.50	1.68	2.60
	($p = 0.52$)	($p = 0.22$)	($p = 0.20$)	($p = 0.11$)

Notes: Numbers in parentheses are *t*-statistics and *, **, and *** indicate the level of statistical significance at 1%, 5%, and 10%, respectively. *RESET* = Ramsey test for functional form misspecification (*F*-distribution); *JBN* = Jarque–Bera test for normality of the error term ($\chi^2(2)$); *HET* = White test for heteroscedasticity (*F*-distribution); and the instrument variables are k_j^d/l_j^d.
Source: Author's estimates are based on data series discussed in the text.

in terms of the standard diagnostic tests. The 2SLS estimates of Eqns. (5.1) and (5.3) are reported in Eqns. (5.2) and (5.4), respectively. Due to the presence of endogeneity problem, the 2SLS estimates are preferable. The regression estimates turn out to be insensitive to the use of the two alternative trade policy variables (*NRP* and *ERP*) except LP^d. For the purpose of estimate comparison, the following discussion focuses on the equation estimated using the 2SLS estimation with *ERP* as the trade policy measure.

The coefficient associated with LP^d in Eqn. (5.2) is negative and statistically insignificant. Interestingly, the estimated coefficient also attains the negative sign and is statistically significant in Eqn. (5.4) where *NRP* is a proxy of *TP*. The results of negative coefficient of LP^d from both equations reject the comment made on previous single-equation-approach studies that FDI likely gravitates to the highly productive domestic sector. [16] The positive and significant estimate of *QL* suggests there exists evidence that labor quality is one of the several factors attracting flows of FDI into Thai manufacturing. This evidence is widely cited by previous studies, for example, Ramstetter (1997) and Tamburlertchai and Ramstetter (1991). Low-cost and high-quality workers in Thailand have attracted foreign investors, especially from East Asian countries, to transplant and use the country as their export base from the late 1980s onward. Nevertheless, the inference drawn from this estimated coefficient must be interpreted with caution because the proxy used is to some extent approximate.

Another interesting result from the FDI determinants equation relates to the degree of protection and size of the domestic market as well as their interaction. Despite the mild level of statistical significance (i.e., at the 10%), the positive and significant coefficient of the interaction term between *ERP* and *MSIZE* supports the hypothesis that, in a small-open economy like Thailand, neither protection nor the size of the domestic market individually is enough to explain FDI determinants. [17] At the given level of *MSIZE*, any increase in the tariff rate invites additional foreign investment to locate and establish plants in order to share the economic rents created by the tariff increase. Similarly, over and above the impact of trade barriers in attracting foreign investors, the larger the domestic market size, the greater the direct investment from abroad.

8. CONCLUSION

This paper examines technology spillover from FDI based on a cross-industry analysis of Thai manufacturing. The prime objective has been to test the "Bhagwati hypothesis" that technology spillover is unlikely to take place in highly trade-restricted industries compared to more export-oriented ones. In order to allow for the simultaneity between sectoral productivity and the foreign presence, this study uses a system of two equations (productivity determinants and FDI determinants) to test the key hypothesis. The regression results fail to reject the "Bhagwati hypothesis." There is also evidence that trade barriers as well as the size of the domestic market play an important role in determining inter-industry differences in FDI participation. These findings also support the "Bhagwati hypothesis." In sum, the results suggest that liberalizing the foreign investment regime while retaining a restrictive trade policy is likely to induce the type of FDI inflows that are unlikely to introduce technology spillover.

NOTES

1. Positive technology spillover from FDI has been found in China, Indonesia, Mexico, Spain, Taiwan, and Uruguay but not in Morocco, Venezuela, India, and the Czech Republic. See the recent survey in Navaretti and Venables (2004).

2. The effective rate of protection (*ERP*) is the proportional difference in value added of a given industry between two situations; free trade and the domestic situation. The higher the *ERP* in an industry, the more domestic policy favors that particular industry. Moreover, the variation between industries implies non-neutrality in tariff structure. See the concept of *ERP* in Corden (1966).

3. The figure reported excludes weaving apparel, ceramic products, and tobacco, whose *ERP*s are to some extent unusually high (i.e., greater than 50% compared to the manufacturing average of 16%).

4. The *ERP* range reported in the text excludes *ERP* of the coconut and palm oil industry, which seems to be an outlier. Its *ERP* estimate is −223%.

5. There are several alternative functional forms such as translog, and constant-elasticity-of-substitution (CES). Choices of the function forms are selected according to the empirical estimates based on the Thai manufacturing data. Based on the diagnostic tests, that is, functional form and residual normality, the Cobb–Douglas form performs better than the others.

6. The production function in Eqn. (1) is transformed into the intensive form to reduce the problem of heteroscedasticity, which may arise from cross-sectional data. Other possible econometric problems, such as simultaneity arising from having endogenous explanatory variables (the inputs L and K), multicollinearity arising from the interdependence of the two inputs, are further reduced by using the intensive form of production (Intriligator, Bodkin, & Hsiao, 1996, p. 289).

7. A higher degree of capital intensity of foreign firms is also found in Thai manufacturing (see Section 2).

8. The approach to measure the technology gap between foreign and local firms is previously used in Sjöholm (1999, p. 61).

9. According to NSO officials reported, information revealed in the survey for 1993–95 mainly involved plant identification (e.g., address, years of operation, registered capital). Most of the variables of interest in this study are not collected properly.

10. The nine variables are registered capital, number of male workers, number of female workers, sale value, values of (initial and ending periods) capital stocks,

value of raw materials, wage paid, and stock of raw materials.

11. The number of duplicated records is at a comparable level to that found in Ramstetter (2004). In particular, Ramstetter (2004) finds around 4,400 duplicated records, which have identical values of 9–10 key variables. Nevertheless, a number of domestically owned plants are higher than Ramstetter (2004), that is, 8,672 plants because Ramstetter (2004) focuses on plants with employment greater than 20 workers.

12. Import-competing *ERP* is calculated under the assumption that there is no tariff exemptions for imported inputs to exporters. Such an assumption is relaxed when calculating export-oriented *ERP*.

13. 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, Kuh, and Welsch (1980) and Barnett and Lewis (1994).

14. These are (1) manufacture of other special purpose machinery; (2) manufacture of accumulators, primary cells and primary batteries; (3) manufacture of office accounting, and computing machinery; and (4) manufacture of insulated wire and cable.

15. Based on *ERP* as *TP*, they are manufacture of grain mill products, manufacture of builders' carpentry and joinery, manufacture of tobacco products, and manufacture of machinery for mining, quarrying, and construction. Regarding the equations based on *NRP*, there are manufacture of grain mill products, manufacture of builders' carpentry and joinery (same as in the *ERP* case) and manufacture of refined petroleum products.

16. Perhaps the negative coefficient found here reflects a pattern of FDI allocation across industries because the value added per worker to some extent could reflect the capital intensity feature of industries. The higher the value added per worker, the more the degree of capital intensity. That is, based on Thai manufacturing across industries, foreign investors tend to participate more in labor-intensive export-oriented industries.

17. The statistical significance of the interaction term is found in the *NRP*-based estimation at the 5% level.

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