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Spillovers and Linkages between Local and Foreign Plants in Thailand Manufacturing Industries

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Abstract

Two possible channels of technology spillover from MNEs to local firms are investigated: diffusion of technological knowledge in the same industry group, and the demand linkage effect where MNEs and local firms are vertically linked in the supply and demand for intermediate goods. Empirical results suggest that in the machinery industry, both spillover and linkage effects exist from MNEs to local suppliers while in resource-based industries, there are negative linkage effects. In resource-based industries, foreign plants are more likely to compete with local producers in the final goods market than the machinery industry. On the other hand, in machinery industries, when foreign plants increase their purchases, local suppliers make use of scale economies and increase productivity. In other words, the relationship between local and foreign plants is complemented.

JEL classification: F15; F23

Keywords: Multinational Enterprises (MNE); Demand linkage; Free trade agreement

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1. Introduction

International trade or foreign direct investment (FDI) inflow affects a local firm's activities in many ways. Among these are linkage and spillover effects which have recently become important in the development of local firms as well as the country as a whole as globalization proceeds. Recent globalization has been led by various types of institutions which include free trade agreements (FTA) and economic partnership agreements (EPA). East and Southeast Asian countries have been deeply involved in globalization mainly though bilateral FTAs and EPAs. From 1992, the Association of South-East Asian Nations (ASEAN) started to formulate the ASEAN free trade agreement (AFTA) and the original five ASEAN member countries, i.e. Indonesia, Malaysia, the Philippines, Singapore and Thailand, have achieved AFTA's targeted tariff reductions (0–5 per cent) in ASEAN trade in 2002. AFTA is just one example of their involvement in globalization. Although there have been many studies that analyse the impact of globalization or FTAs on the local economy, little research has been done on the changes in economic linkage between multinational enterprises (MNEs) and local firms. In most Asian, especially Southeast Asian countries, MNEs have a crucial role for their economic development. Research on the changing structure of linkages between MNEs and local firms is indispensable for understanding the development process of these countries. This paper focuses on this issue.

There are two types of linkage effects: forward and backward. Forward linkage effects between MNEs and local firms arise when an MNE sells its intermediate goods to local producers, while backward linkage effects arise when an MNE purchases input goods from local suppliers. It is generally expected in developing countries that backward linkage effects are more likely to occur than forward linkage effects. Javorcik (2004) analyses the effects of MNEs' backward and forward linkages on MNEs' and local firms' productivity in Lithuania using plant-level data and suggests that the spillovers of knowledge from MNEs occur through mainly backward linkage effects. Lin and Saggi (2006) construct an oligopoly model that explains the spillovers through backward linkage.[1] However, these linkage effects are not necessarily always positive. Negative linkage effects may exist when the arrival of MNEs leads to the exit of less productive local firms from the market, which in turn contributes to increased industrial productivity. From the local firm's point of view, however, this is a negative linkage effect. There are a few empirical studies that have been done on this type of linkage effect. In addition to Javorcik (2004),[2] Kugler (2006) finds the positive externality effect of demand linkage (FDI diffuses technological knowledge to local upstream suppliers) in Colombian manufacturing sectors.

On the other hand, there is a great variety of literature on the trade/FDI impact on firms' (local and MNEs') productivity, such as Pavcnik (2002) for Chile, Fernandes (2006) for Colombia, Amiti and Konings (2005) for Indonesia, Topalova (2004) for India and Muendler (2004) for Brazil, to name just a few. There are mainly three channels for this impact. First, an increase in foreign competition fosters process innovation. Second, import input materials often contain foreign advanced technology. Hence, trading these materials reinforces technology transfer.

1. Two important theoretical articles on backward linkage effects from MNEs to local firms are Rodriguez-Clare (1996) and Markusen and Venables (1999) which construct a model in the monopolistic competition framework. See Lin and Saggi (2005) for a recent survey of linkage effects.
2. Javorcik (2004) analyses the impact of MNE presence on *total* (MNEs and local) firms' productivity, while this paper focuses on the effects of MNE presence on the *local* firms.

Third, foreign pressure forces less efficient firms to exit from the market. Eventually, only efficient firms remain and an industry level productivity increases.

This paper contributes to the literature in an important respect. Focusing on the case of Thailand, I provide evidence that there are positive and negative linkage effects and spillover effects of MNEs depending on the type of industry. These findings confirm the results in the literature listed above, but at the same time suggest reservations about the existence of effects.

Before proceeding with analysis, let us look at an overview of the industry characteristics of ASEAN. The structure of industries has changed over time in ASEAN. Table 1 shows some industry information about these countries. Except for the Philippines, the growth rates of the original member countries (Indonesia, Malaysia, Singapore, Thailand) after the Asian crisis are much lower than those before. On the other hand, many new member countries such as Cambodia, Lao and Vietnam have achieved high economic growth after the crisis. Table 1 also reveals another notable finding: that the manufacturing growth rate (fourth column) exceeds the GDP growth rate (third column) in all countries after the crisis except for the Philippines. As a result of this, the share of the manufacturing sector expands for all countries except for the Philippines (fourth column). Although the impact of the Asian crisis was serious, this indicates that the manufacturing sector has been a leading sector for economic growth in many ASEAN member countries.

<Table 1 near here>

Thailand is a typical example of a country that has achieved high economic growth led by liberalizing manufacturing sectors and also by FDI inflow in many sectors. However, there are few empirical studies on Thailand’s trade liberalization and FDI structure. Urata and Yokota (1994) analyse the impact of trade liberalization on the industry productivity in Thai manufacturing sectors and find positive effects of liberalization on productivity. Recently, Milner et al. (2004) studied the vertical FDI structure of Japanese MNEs in the manufacturing sector in Thailand and find that the Japanese FDI in Thailand is generally of a vertically integrated nature.

In the following sections, I used the Thai plant-level data set to investigate these effects on local firms.[3] This paper is organized as follows. The next section provides industry characteristics and discusses the adjustment process of each industry group. Section 9.3 introduces the empirical model and discusses the results. Section 9.4 discusses the results of the previous section more carefully and impact of FTA. Section 9.5 discusses the impact of FTAs on local plants and section 9.6 concludes the paper.

2. Industrial structure and local–multinational linkages in Thailand

2.1 Categorization of industry

To show the results in a simpler fashion and to make analyses sharper, 2-digit international standard industrial classification (ISIC) industries which have 22 sectors[4] were aggregated into four categories: resource-based, machinery, labour-intensive, and metal and chemical. The results of the categorization are reported in Table 2.

<Table 2 near here>

To categorize industries, three different ratios were calculated:

3. I use plant-level, not firm-level, data from industrial surveys of Thailand. Although, to be precise, a foreign plant is not equal to an MNE, I use the terms ‘foreign plant’ and ‘MNE’ interchangeably hereafter.
4. See Appendix Table 10 for these sector classifications. I exclude sector 37: recycling, from my analyses, because some other main data sources do not have the recycling sector.

resource-input, machinery-input and labour-input. All information for this calculation comes from input–output (IO) tables compiled by the National Statistical Office (NSO), Thailand. The average of the ratios of three input–output tables of 1995, 1998 and 2000 was used.

Resource-input ratio is defined as the ratio of resource inputs over total intermediate inputs. Resource inputs are composed of ISIC 3-digit codes from 001 to 044 including agricultural products (001–017), logging (025), forestry products (027), crude oil and natural gas (031), iron ore (032), tin ore (033) and fertilizer (037). Intermediate inputs include all agricultural, manufacturing and services sectors. This category includes coke, refined petroleum products (23), food products (15), wood products (20), rubber and plastic products (25), and tobacco (16) and so on. Industries categorized as resource-based have very high resource-input ratio ranging from 0.21 to 0.49. It is also notable that these industries have relatively lower machinery-input ratios as shown in the second column of Table 2.

The machinery industry is composed of industries that have relatively higher machinery-input ratios, defined as the ratio of machinery inputs to the total intermediate inputs. The category of machinery that is used for this ratio includes general machinery (29), computer (30), electric machinery (31), TV, radio (32), precision (33), motor vehicles (34) and other transportation equipments (35). As expected, the industries with high machinery-input ratios are the machinery industries themselves. Each industry included in this category has a very high machinery share ranging from 0.74 in machinery and equipment (29) to 0.47 in other transport equipment (35).

The labour-intensive industry is categorized according to the labour-input ratio. Labour-input ratio is defined as the share of total labour inputs in industry *j* in total intermediate inputs. Labour input is defined as the total wage payments in industry *j*. The labour-intensive group includes furniture (36), leather manufacture (19), textiles (17) and wearing apparel (18).

The final category is the metal and chemical industry. This group is characterized by lower resource ratios, lower machinery input ratios, and relatively lower labour-intensiveness. This category is named after the industries included in the group, such as basic metals (27), fabricated metal products (28) and chemicals and chemical products (24).

2.2 Direction of industrial adjustment

Using this categorization, the next task is to examine the direction of industrial adjustment, especially in output and productivity, by the four industry groups. To see the direction of the adjustments of industry's outputs and productivity, the weighted productivity was decomposed into two parts: unweighted productivity and covariance between unweighted productivity and weight, i.e. the plant's output share of the industry output as in Olley and Pakes (1996) and Pavcnik (2002). This decomposition was computed by year and industry group. The decomposition formula is the following:

$$\overline{w}_t^{\,j} = \sum_i s_{it}^j p_{it}^j = \overline{p}_t^{\,j} + \sum_i (s_{it}^j - \overline{s}_t^{\,j})(p_{it}^j - \overline{p}_t^{\,j}) = \overline{p}_t^{\,j} + \sigma_s \sigma_p corr(s_{it}^j, p_{it}^j), \qquad (1)$$

where $\overline{w}_t^{\,j}$ is the weighted average of productivity in industry *j* and year *t*. Productivity p_{it}^j is labour productivity which is defined as value-added per production worker. s_{it}^{j} and $\bar{s}_{t}^{j}$ are the plant's share of the industry output of plant *i*, industry *j*, and year *t*, and an industry average of the variable. The last equation converts the variance to the correlation expression, denoting standard deviations of weight and productivity by σ_s and σ_p respectively. The covariance component represents and reveals the reallocation of output share and the plant's productivity level. If the covariance is positive, we infer that more outputs in the industry are produced by more efficient plants. In other words, the reallocation of the resources from less to more productive plants in the industry occurs if the covariance term is positive.

<Table 3 near here>

Instead of covariance as used in other literature, the Pearson correlation index was used as well as the Spearman rank correlation that can test statistical significance. However, the interpretation is exactly the same as the discussion above. Table 3 shows the results of the correlation between the plant's productivity and output share in each industry group. As expected, all correlation coefficients are positive and almost all are statistically significant at 0.1 per cent level both in Pearson and Spearman Rank correlations. This means that in each year and each industry group, resource had been reallocated from less to more productive plants in industry *j* in time *t*. Another notable finding from Table 3 is the importance of MNE presence in industry. In Table 3, the share of numbers and share of output indicate the share of MNE numbers in the total number of plants in its industry group, and the MNE's output share in its industry group, respectively. Comparing 1996 and 2002, we notice that all industry groups reduce their shares in numbers but raise output shares, except for the labour-intensive industry. This means the emergence of a more oligopolistic situation in resource-based, machinery, and metal and chemical industry groups. An astonishing fact is the high output share in the machinery industry. It is inferred from this fact that MNEs play an important role in the Thai manufacturing industries, especially the machinery industry group.

3. Spillover and linkage effects

3.1 Estimation strategy

In this section, I specify the possible effects of a foreign plant on the local plant's productivity. Two possible channels of technology spillover from MNEs to local firms are investigated: diffusion of technological knowledge in the same industry group, and the demand linkage effect where MNEs and local firms are vertically linked in the supply and demand for intermediate goods. In the case of knowledge diffusion, the extent of foreign presence in an industry affects the local firm's productivity in the same industry.

In the second case, demand linkage effects can be broken into two sub-effects: backward and forward. Backward linkage effects occur when MNEs purchase inputs from local suppliers, in other words, when MNEs grow, local suppliers also grow. On the other hand, forward linkage effects occur when MNEs provide inputs to local (often final) producers. As mentioned in the introduction and as described in Javorcik (2004), Lin and Saggi (2006) and Kugler (2006), it is plausible that backward linkage happens more often in developing countries than forward linkage. I therefore focus on the backward linkage effect in this paper.

There are two directions of these two effects on local firms. First, a local plant's output reduces due to being crowded out by foreign plants. Second, a local plant's output increases due to linkage effects by foreign plants.[5] Which effect is stronger crucially depends on the characteristics of the industry and this is an empirical issue.

However, casual observations indicate that the first case occurs when MNEs sell the same products as local plants, and then MNEs take a large share of the market from local producers. It may often happen in the industry that MNEs compete with local producers for final goods, for example, food products, rubber goods, textiles, apparel, and metal product industries. Those can be basically categorized in resource-based, labour-intensive, or metal industries.

On the other hand, the second case often happens in the differentiated products or vertically linked industries, such as electric machinery, motor vehicles and computer industries that are categorized in the machinery industry in this paper. In these sectors, MNEs purchase inputs from local suppliers to produce final goods. The spillover effect is captured by estimating the effect of foreign presence on the local plant productivity. I specify a foreign presence variable, MNE_{jt}. MNE_{jt} expresses the extent of foreign presence in sector *j* at time *t* and is defined as foreign equity participation in that sector. MNE_{jt} is defined as follows:

$$MNE_{jt} = \frac{\sum_{i \in j} foreign\ plant\ output_{ijt}}{\sum_{i \in j} all\ plant\ output_{ijt}}$$

5. It is possible that a local firm's output expands due to the exiting of inefficient other local firms after the entrance of MNEs into the market. However, exit data are not available for Thailand, so I have to exclude this possibility from analyses in this paper.

Using the plant-level pooled cross-section data set, I estimate the following equation:

$$p_{ijt} = \alpha_0 + \alpha_j \delta_j + \alpha_t \delta_t + \alpha_1 MNE_{jt} + (\alpha_2)' Z_{ijt} + \varepsilon_{ijt}, \qquad (2)$$

where p_{ijrt} is labour productivity of plant *i* in industry *j* in region *r* and in year *t* in logarithm. Labour productivity is defined as the ratio of the plant's value-added to the number of production workers in that plant. MNE_{jt} is calculated at each 3- and 4-digit ISIC level of industry *j* and year *t*, Z_{ijrt} is a vector of local plant's and industry's characteristics, such as plant age, plant size, plant's trade activities, such as export and import and α_j, α_t are industry effects, and year effects, respectively.

The operating years of plants and its square terms are included to account for heterogeneity in productivity as in Fernandes (2006). Operating years and its square term are taken logarithm. Plant size is included in the estimation for controlling plant heterogeneity. The logarithm of the number of production workers in that plant is used for the proxy of plant size. Since labour productivity does not capture the contributions of capital, another important control variable for labour productivity is necessary. Capital-labour ratio is a proxy for the contribution of capital which is defined as the ratio of capital in terms of a million Thai baht to the number of production workers in the plant.

Plant-level information about its external activities such as export and import is also important in accounting for its productivity. If the local plant exports its product to the world market, it indicates a strong plant's competitiveness or that plant learns from exporting. On the other hand, if the local plant imports, it can learn new technology from the imported intermediate goods and from the interaction with the world market.

The positive sign is expected for the estimated coefficient on foreign presence if spillover from the foreign plants to local plants exists. The expected signs of coefficients on capital-labour ratio, plant size, export and import are therefore positive. If labour productivity increases as a plant accumulates experiences but that experience diminishes as a plant becomes old, the sign on plant age would be positive while the sign on age-squared would be negative.

As I mentioned above, there are two main effects of MNEs on local plants: spillover and demand linkage effect. I implicitly assume that this spillover effect occurs within the same sectors. In this sense, the presence of MNEs affects local plants horizontally, as is described in Javorcik (2004). However, the spillover effect can affect local plants across sectors which I refer to as the linkage effect in the previous section. To examine the correlation between plant productivity and FDI across sectors, it is useful to consider the linkage effect of MNE.

$$p_{ijt} = \beta_0 + \beta_j \delta_j + \beta_t \delta_t + \beta_1 Linkage_{jt} + (\beta_2)' Z_{ijt} + \varepsilon_{ijt}, \tag{3}$$

where $Linkage_{jt}$ is a proxy for a demand linkage effect defined as follows:

$$Linkage_{jt} = \ln\left(\sum_{h \in H} intermediate\,demand_{jht} * MNE_{jt}\right).$$

$Intermediate\,demand_{jht}$ is the total value (in logarithm) of intermediate demand of foreign plants in industry *j* for industry *h* and time *t*. In other words, the independent variable linkage captures the intermediate demand for all sectors (denoted by *H*) by the foreign plants in industry *j*. Demand linkage externality from MNEs to local suppliers occurs when MNEs increase their demand for intermediate inputs which in turn lead scale economies to local suppliers in the upstream. $Linkage_{jt}$ is calculated from the transaction matrices of IO tables for three years, 1995, 1998 and 2000.

3.2 Data

Plant-level data are compiled from the NSO, Thailand, which contains information on plant sales, employment, raw materials, equity, existence of export and import, and year of start-up operations, etc. The survey data of five years, 1996, 1998, 1999, 2000 and 2002, are used for the analyses. The 1996 data come from the census data while the other years come from survey data. The coverage of the survey varies from year to year. The final sample for estimation has about 35,000 observations. The NSO conducted surveys on manufacturing establishments by using the combination of stratified sampling and systematic sampling. The NSO stratified establishments in each province according to industry codes and the number of workers. Then samples were selected from each province-industry-worker stratum using systematic sampling.

Industry categorization and some variables such as linkage effect are calculated from IO tables, compiled by the NSO. IO tables of 1995, 1998 and 2000 are used for this study. Each IO table is converted into 2-, 3- and 4-digit ISIC codes of the industry survey code (ISIC). I used IO tables of 1995 for 1996 industrial census, and 1998 IO tables for 1998 and 1999 industrial survey data, and IO tables of 2000 for 2000 and 2002 survey data respectively. This treatment lessens the reverse causality problem: the presence of MNEs raises or decreases the local plant's productivity because of linkage effects; on the other hand, efficient labour attracts MNEs from abroad. All variables are deflated by appropriate price indices which come from the Bank of Thailand.

Table 4 contains the summary statistics of variables used in estimation. Some notable features should be addressed. First, the metal and chemical industry has the highest average labour productivity, followed by the machinery industry. Second, averages of foreign presence and demand linkage are very high in the machinery industry. Third, the share of exports is relatively high in machinery and labour-intensive industries, while import share is the highest in machinery followed by the metal and chemical industry. In general, the machinery industry, on average, has a strong connection with the world market. The last notable feature of the variable is that the average output and average value-added are the highest in the machinery industry. It is almost five times larger than the per capita output in labour-intensive industry.

<Table 4 near here>

3.3 Estimation results

Table 5 reports the estimation results of equation (2). Equation (2) is estimated using ordinary least squares (OLS). Table 5 is divided into four groups according to the categorization in Table 2. All estimations include capital-labour ratio, plant size measured as the logarithm of number of production workers, plant age which equals the logarithm of operating years of the plant, the square term of plant age, and status of international trade, that is, export and import, as explanatory variables. Trade status variables are binary, i.e. if the plant exports (imports), the variable takes 1 and zero otherwise. Year effect is included in all specifications.

It may be assumed that aside from foreign presence, there is heterogeneity across industries which may affect plant's productivity. Hence, the heterogeneity across industry should be taken into account when the equation is estimated. For removing this effect and controlling for unobservable shocks across industry, the industry effect is included in all estimated equations.

Since foreign presence and industry effects are calculated at both 3- and 4-digit ISIC level, the possible correlation (multi-colinearity) between foreign presence and industry effect calculated at 3- and 4-digit ISIC level should be taken into careful consideration. Hence, I estimate four different specifications for each group: the first specification includes foreign presence at 3-digit ISIC level and industry effect at 3-digit ISIC level. The second estimation of each group has a combination of 3-digit foreign presence with 4-digit industry effect. The third specification has foreign presence calculated at 4-digit ISIC level as a dependent variable with 3-digit industry effect as an independent variable. The fourth specification includes 4-digit foreign presence and 4-digit industry effect.

<Table 5 near here>

There are some notable results in Table 5. Among the four industry groups, only the machinery industry has positive and significant coefficients on foreign presence at both 3- and 4-digit levels. Coefficients on foreign presence at 3-digit in resource-based industries are negative and statistically significant. In other industry groups, such as labour-intensive and metal and chemical industries, coefficients on foreign presence are negative although insignificant.

Coefficients on other independent variables have corrected (expected) signs in all industry groups and all specifications and almost all coefficients are highly significant. A positive coefficient on plant size indicates that a relatively large plant in terms of the number of employees makes use of scale economies. A positive coefficient on plant age together with a negative coefficient on age-squared mean that the plant productivity increases as it ages, but its rate of growth diminishes. This can be observed in all industry groups with highly statistical significance except for resource-based industries. Although coefficients on plant age and age-squared are not significant, they have correct signs in resource-based industry.

A positive sign on export and import are expected and estimation results confirm this. The export activities of plants are strongly correlated with high labour productivity in resource-based, labour-intensive, and metal and chemical industry groups. Machinery industry has a positive coefficient on exports but this is not statistically significant. On the other hand, coefficients on imports are positive with statistical significance in all industry groups and for all specifications. It simply means that the import activity of a plant is strongly correlated with high plant productivity no matter what the industry group is. This result also supports the idea of a spillover through imported intermediate goods channels.

Another interesting question to ask is how demand linkage effect works. Table 6 summarizes the results and shows that demand linkage effect is observed in the machinery industry but not in other industry groups.

<Table 6 near here>

Out of four specifications in the machinery industry, three specifications – columns (5), (6) and (7) – show positive and statistically significant demand linkage effects. These show that demand linkage is positively correlated with plant productivity. On the other hand, in resource-based, labour-intensive, and metal and chemical industry groups, demand linkage is negatively correlated with plant productivity.

Tables 5 and 6 demonstrate that foreign plants have both positive spillover and linkage effects on local plants in the machinery industry, and negative spillover and demand linkage effects in resource-based industries. Import has a positive correlation with local plants' productivity both in spillover and demand linkage effect channels in all industry groups. This finding, combined with the extent of import activity of a plant (Table 4), indicates that more competitive pressure from imports may affect linkage and spillover effects on local plants and may lead a hypothesis that imported intermediate goods help increase local plants' productivity.

4. Further discussion on spillovers and demand linkage effects, and trade liberalization

In the previous section, I have shown that spillover and linkage effects exist in the machinery industry while there are negative linkage effects in resource-based industries. Estimated coefficients also show a negative sign in labour-intensive and metal and chemical industries although they are not statistically significant. Why do empirical results show the opposite directions regarding the effects of spillover and linkage on plant productivity? One possible explanation is the following: in resource-based, labour-intensive, and metal and chemical industries, such as coke and petroleum products, food products, tobacco, wood products, rubber goods, textiles, wearing apparel, and paper products industries, foreign plants are more likely to compete with local producers in the final goods market than the machinery industry. In other words, the relationship between local and foreign plants is substituted. On the other hand, in machinery industries, such as electric machinery, motor vehicles and computer industries, foreign plants are more likely to purchase from local suppliers probably in the vertical production network. In this case, when foreign plants increase their purchases, local suppliers make use of scale economies and increase productivity. In other words, the relationship between local and foreign plants is complemented.

The results in the previous section also indicate that trade status, especially imports, has a strong positive impact on local plant productivity in all groups and for all specifications.

In this section I provide more detailed information on both linkage and spillover effects, and then I will discuss the impact of FTA. To examine the results of the previous section carefully, I calculated average values of variables used in the estimation. Each variable is averaged separately according to the type of ownership, i.e. local and foreign. Table 7 shows the average values of variables. The ratio in the table indicates the ratio of the average value of foreign to local plants.

<Table 7 near here>

Combining Table 4 with Table 7, we have the following findings. The most notable finding is that the difference in output and value-added per plant between local and foreign plants is much larger in the machinery industry than in other industries. Average output (value-added) by foreign plants is 20 (17.6) times larger than that of local firms in the machinery industry, while foreign plant output (value-added) ranges from 4.7 (4.2) to 6.9 (5.4) times larger than local plants in resource-based, labour-intensive, and metal and chemical industry groups.

The second notable finding is that an average foreign plant size measured by the number of production workers is 7.4 times larger than an average local plant in the machinery industry, a figure that is much greater than for other industry groups.

The third notable finding is that about 42 per cent of local plants and more than 90 per cent of foreign plants import intermediate goods from the world market which are much higher than the cases of resource-based, labour-intensive, and metal and chemical industries.[6]

The last finding is that the average protection rate measured by the ratio of import tariffs and duties to the total imports at 4-digit ISIC is the lowest in the machinery industry which shows 14.9 per cent in all industry groups (this figure comes from Table 4). Coupled with the finding about import status, this suggests that the machinery industry enjoys the benefits of trade liberalization. However, this will be discussed in the next section.

To explain the difference between the results of machinery and other industry groups on spillover and demand linkage effects, especially a large output difference between local and foreign plants, these insights should be taken into consideration. The most reasonable explanation of this difference in results is that the vertical production network prevails in the machinery industry while the horizontal competition dominates in resource-based and other industries. In order that the vertical network functions well in the industry, demand linkage should be strong and in order to have strong demand linkage, foreign presence should be large in that industry. Table 4 already reported that in the machinery industry, the average values of foreign presence and demand linkage are relatively large compared with the case of other industries. For example, foreign presence at 3-digit ISIC of machinery industry is 0.74 while 0.35 in resource-based industries, 0.42 in labour-intensive industries, and 0.48 in metal and chemical industries. As for the

6. Export (import) is a binary variable which takes 1 if the plant exports (imports), zero otherwise. Hence the average values for export and import in Table 7 show the percentage of the plants that export or import in the industry group.

demand linkage, an average linkage in the machinery industry at 3-digit ISIC is 13.3 while it is 6.3 in resource-based, 6.9 in labour-intensive, and 8.7 in the metal and chemical industries.

Another important finding is the large difference in size between local and foreign plants in the machinery industry. This, combined with the vertical network hypothesis, shows how the large foreign plants dominate a lion's share of the market, and have a linkage nexus with small upstream local suppliers in the machinery industry. Since local plants are so small (20 times smaller than foreign plants in the machinery industry), they cannot survive if they compete with foreign plants in the final goods market. Instead of competing with foreign plants, local plants can survive to provide intermediate goods to downstream large foreign plants in the vertical production network. It is possible to assume that large and influential foreign plants transfer advanced technology and knowledge to small and upstream local plants through the expanding demand for intermediate goods.

Since there is a large gap in output size between foreign and local plants in the machinery industry, it is interesting to ask how this gap affects the local plant's productivity in different industries. Casual observation suggests that a narrow gap between local and foreign outputs allow a small local plant to catch up with foreign plants while a large gap makes it difficult for a local plant to get benefits from spillovers.

Figure 1 is a scatter diagram of local plants' productivity and output difference between local and foreign plants in resource-based, labour-intensive, and metal and chemical industries. Output difference is defined as the logarithm of the ratio of the local plant's output to the average output of foreign plants in each industry calculated at the 4-digit ISIC level.[7]

<Figure 1 near here>

Figure 2 is a scatter diagram of local plants' productivity and output difference between local and foreign plants in the machinery industry. A positive correlation between two variables is observed although the slope in Figure 2 is flatter than that in Figure 1. From the above observation, in the machinery industry, the output difference between local and foreign plants is not as sensitive to the local plants' productivity as other industry groups.

<Figure 2 near here>

Figures 9.1 and 9.2 clearly show a positive correlation between two variables. However, there are two interpretations of this fact: a catching-up hypothesis and an existence of scale economies in which the larger the size of output, the higher the labour productivity. It is difficult to distinguish between a catching-up hypothesis and the existence of scale economies from the information of these two graphs.

Hence, I tested the catching-up hypothesis directly by regressing the labour productivity of each plant on output difference and the square term of output difference including year and industry effects. If a catching-up hypothesis holds, the coefficient on the difference is positive and the coefficient on the square term of difference is negative. In other words, labour productivity increases as output difference becomes smaller, but the rate of increase in productivity diminishes, i.e,

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7. The output difference is calculated as $\ln\left(Y_{i,j,t} \big/ \overline{Y}_{MNE,j,t} \right)$, where $Y_{i,j,t}$ equals output of plant *i*, industry *j*, and year *t*, while $\overline{Y}_{MNE,j,t}$ equals an average of foreign plant outputs in industry *j*, at year *t*.

the relation between productivity and output difference shows an inverted-U shape. Table 8 reports the estimation results. Salient findings are that all coefficients in all industries have expected signs and are highly statistically significant. The results confirm the hypothesis that a narrower gap in the size of plants is important for local plants to catch up with foreign advanced technology.

<Table 8 near here>

The results also show that the coefficient on square term of output difference in the machinery industry is smaller than those in other industries. This indicates that in the machinery industry the slope of the curve is flatter than those in other industries. In other words, there is a weaker connection in the machinery industry between productivity and output gap than in other industries. Despite this finding, why does the machinery industry have a positive and strong spillover as well as linkage effects?

All these observations suggest the following possible explanation: in the machinery industry, the output gap helps technology transfer in that a vertical production network between small local and large foreign plants prevails and spurs the knowledge spillover from a large foreign to a small local plant through backward linkage effects.

5. FTA and its impact on local plants

As Tables 9.5 and 9.6 show, export and import activities have strong impacts on plant productivity. In particular, imports have a positive and highly significant coefficient in all industry groups. On the other hand, Thailand has engaged in FTAs with China, Australia, New Zealand and India, and is planning to conclude EPAs with Japan and the USA.[8] While Thailand has been involved in AFTA since 1992, the common effective preferential tariff (CEPT) scheme reached the targeted tariff rate (0–5 per cent) among ASEAN5 in 2002. Institutional agreements may spur the international trade of local plants and then raise plant productivity. Liberalization in international trade barriers, no matter whether institutional or natural, affects local plant activity. In this section, I discuss the relationship between FTA and local plant productivity.

To estimate the correlation between FTA and plant productivity, I regress the local plant's productivity in logarithm on the degree of protection that is measured as a share of import tax plus import duty in total imports in industry *j*. Protection is calculated at the 4-digit ISIC level.[9] If industry *j* is more liberalized, that is, has a lower protection rate, plant productivity increases though the expansion of import and export. Thus, the expected sign of coefficient should be negative. Year effect and industry effect are included in the estimation.

Table 9 summarizes the results. In the case of a total sample, the coefficient on protection is negative and statistically significant in column (1) but insignificant in column (2). Results with different industry effects do not show consistent evidence. For a total sample case, the correlation between trade liberalization and productivity is, therefore, ambiguous.

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8. On 19 September 2006, a military coup took place. Under a new interim cabinet with Prime Minister Surayud Chulanont, many mega-projects and ongoing negotiations of EPAs may be shelved for at least one year.
9. I also use 3-digit data to calculate the share of import tax and import duty, but there is multi-colinearity between 3-digit protection and industry effects. Thus the results at 3-digit protection are not reported here.

In machinery and labour-intensive industry groups, coefficients on protection show negative signs and are statistically highly significant for both industry effects cases. It would be safe to say that liberalization by the FTA/EPA has a positive impact on productivity in machinery and labour-intensive industries. This confirms other related literature, listed in the introduction.

<Table 9 near here>

On the other hand, in resource-based and metal and chemical industry groups, coefficients on protection are positive but some of them are statistically insignificant (columns (3) and (9)), indicating that trade liberalization does not have a definite effect on a plant’s productivity in these industries. In sum, it reveals that the impact of trade liberalization differs from industry to industry.

6 Conclusion

This study has focused on the empirical analysis of the effects of MNEs on local plants by using plant-level data from Thailand. More specifically, this paper has examined the spillover and linkage effects of MNEs on local plants. The linkage effect occurs when MNEs purchase input materials from local suppliers (through backward linkage) or MNEs sell intermediate goods to local producers (through forward linkage). However, it is possible for MNEs to affect local plants negatively. This happens when the MNEs compete with local firms in the same market and MNEs take a large share of the market.

Empirical results suggest that in the machinery industry, both spillover and linkage effects exist from MNEs to local suppliers while in resource-based industries, there are negative linkage effects.

This paper has also examined the relationship between the output gap of plants and plant productivity. The conclusion supports the casual observation in which narrow output gaps between local and foreign plants are strongly correlated with higher productivity in all industries. In other words, a local plant has more chances to catch up with advanced technology provided by foreign plants when the output gap is small.

To explain why only the machinery industry has positive spillover and linkage effects, it is reasonable to refer to the vertical production nature of the industry. It may be assumed that small local plants produce and sell their products to large and downstream foreign plants in the machinery industry. In this case, small local plants can avoid direct competition with foreign plants in the final goods market. In addition, small local plants can benefit from the expanding demand of intermediate goods though the demand linkage effects.

I also showed the FTA impact on local plants by examining the effects of trade liberalization. Results suggest that protection is strongly and negatively correlated with a local plant’s productivity in machinery and labour-intensive industries but not in resource-based and metal and chemical industries. This result suggests that FTA/EPA has a favourable impact on productivity improvement in machinery and labour-intensive industries but the effects of FTA/EPA vary according to the type of industry.

A simple implication derived from these findings is that establishing competitive suppliers in the upstream in an industry such as the machinery industry is crucial to bear fruits of FTA/EPA.

References

Amiti, M. and J. Konings (2005). ‘Trade Liberalization, Intermediate Inputs, and Productivity: Evidence from Indonesia’, IMF Working Paper.

Fernandes, A. M. (2007). ‘Trade Policy, Trade Volumes and Plant-level Productivity in Colombian Manufacturing Industries’, *Journal of International Economics*, 71, 52-71..

Javorcik, B. S. (2004). ‘Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages’, *American Economic Review*, 94, 3: 605–27.

Kugler, Maurice (2006). ‘Spillovers from Foreign Direct Investment: Within or Between Industries?’ *Journal of Development Economics*, 80, 444-477.

Lin, P. and K. Saggi (2005). ‘Multinational Firms and Backward Linkages: a Critical Survey and a Simple Model’, in M. Blomstrom, E. Graham and T. Moran (eds), *Does Foreign Direct Investment Promote Development?* Institute for International Economics, Washington, D.C.

Lin, P. and K. Saggi (2007). ‘Multinational Firms, Exclusivity, and Backward Linkages’, *Journal of International Economics*, 71, 206-220.

Markusen, J. R. and A. Venables (1999). ‘Foreign Direct Investment as a Catalyst for Industrial Development’, *European Economic Review*, 43: 335–56.

Milner, Chris, Geoff Reed and Pawin Talerngsri (2004). ‘Foreign Direct Investment and Vertical Integration of Production by Japanese Multinationals in Thailand’, *Journal of Comparative Economics*, 32: 805–21.

Muendler, Marc-Andreas (2004). ‘Trade, Technology, and Productivity: a Study of Brazilian Manufacturers’, http://repositories.cdlib.org/ucsdecon/2004-06

Olley, S and A. Pakes (1996). ‘The Dynamics of Productivity in the Telecommunications Equipment Industry’, *Econometrica*, 64: 1263–97.

Pavcnik, N. (2002). ‘Trade Liberalization, Exit, and Productivity Improvement: Evidence from Chilean Plants’, *Review of Economic Studies*, 69, 1: 245–76.

Rodriguez-Clare, A. (1996). ‘Multinatinals, Linkages, and Economic Development’, *American Economic Review*, 86: 852–73.

Topalova, Petia (2004). ‘Trade Liberalization and Firm Productivity: the Case of India’, IMF Working Paper WP/04/28.

Urata, S. and K. Yokota (1994). ‘Trade Liberalization Policies and Productivity Change: A Case of Thailand’, *Developing Economies*, 32, 4: 444–58.

Table 1: Industrialization in ASEAN

Country	Period	Growth rate of GDP	Growth rate of Manufacturing	Share of Manufacturing
Indonesia	1988-1996 1998-2005	7.8% 4.1%	10.7% 4.9%	23.4% 27.8%
Malaysia	1988-1996 1998-2005	9.0% 5.2%	13.1% 6.9%	26.4% 31.1%
Philippines	1988-1996 1998-2005	3.2% 4.4%	3.0% 4.0%	23.0% 22.3%
Singapore	1988-1996 1998-2005	8.5% 5.1%	7.5% 6.7%	25.2% 24.7%
Thailand	1988-1996 1998-2005	8.6% 4.8%	11.6% 7.0%	27.9% 34.1%
Brunei	1988-1996 1998-2004	1.4% 2.8%	0.0% 3.6%	43.6% 41.2%
Cambodia	1988-1996 1998-2004	N.A. 7.1%	N.A. 16.7%	9.0% 18.6%
Lao	1988-1996 1998-2004	6.9% 6.1%	16.2% 9.4%	12.5% 18.4%
Myanmar	1988-1996 2001-2003	N.A. 4.0%	N.A. 8.3%	9.0% 20.1%
Vietnam	1988-1996 1998-2005	7.2% 6.6%	5.2% 10.3%	15.2% 19.6%

Note: Figures are calculated based on 2000 constant price.

Source: Asian Development Bank (2006), *Key Indicators 2006* (http://www.adb.org/Documents/Books/Key_Indicators/2006/default.asp)

Table 2: Categorization of industries

Groupe	ISIC	Industry	Resource	Machinery	Labor
1. Resorce-based Industry	23	Coke, refined petroleum products	0.81026	0.00348	0.04157
	15	Food products and beverages	0.49483	0.01514	0.09567
	20	Wood and of products of wood	0.42601	0.03401	0.16250
	25	Rubber and plastic products	0.26524	0.00803	0.11933
	26	Other non-metallic mineral	0.20555	0.03742	0.18902
	16	Tobacco products	0.16361	0.02201	0.26821
2. Machinery Industry	29	Machinery and equipment n.e.c.	0.00044	0.74023	0.05525
	30	Office, accounting and computing	0.00000	0.73412	0.08677
	31	Electrical machinery	0.00243	0.70807	0.12314
	32	Radio, television	0.00123	0.58214	0.12669
	33	Medical, precision and optical	0.00000	0.51375	0.14836
	34	Motor vehicles, trailers	0.00644	0.49820	0.15422
	35	Other transport equipment	0.00332	0.47034	0.10377
3. Labor-intensive Industry	36	Furniture manufacturing n.e.c.	0.01128	0.01899	0.30627
	19	Tanning and dressing of leather manufacture	0.08704	0.01719	0.18906
	17	Textiles	0.08608	0.01686	0.17478
	18	Wearing apparel dressing	0.00062	0.00647	0.17142
4. Matal and Chemical Industry	27	Basic metals	0.07748	0.01825	0.16538
	22	Publishing, printing and reproduction of record	0.00000	0.01767	0.16164
	28	Fabricated metal products	0.00122	0.01514	0.15151
	24	Chemicals and chemical products	0.04660	0.01693	0.12084
	21	Paper and paper products	0.02809	0.01528	0.07870

Notes: Resource: resource inputs / total intermediate inputs, Labour: total wage payments / total intermediate inputs, Capital: machinery inputs / total intermediate inputs.

Sources: Input–Output Tables, 1995, 1998, 2000, National Statistical Office, Thailand.

Table 3: Directions of resource reallocation

		1996		1998		1999		2000		2002	
		Local	MNE	Local	MNE	Local	MNE	Local	MNE	Local	MNE
1. Resorce-based Industry	Pearson	0.1996*	0.2514*	0.2075*	0.3923*	0.1761*	0.0727	0.1665*	0.0854	0.1316*	0.3625*
	Spearman	0.5632*	0.5216*	0.7049*	0.5474*	0.7206*	0.5421*	0.6027*	0.3474*	0.6961*	0.4765*
	Share of Numbers	12.6%		7.6%		6.9%		7.7%		7.8%	
	Share of Output	33.3%		42.2%		52.7%		47.8%		49.4%	
2. Machinery Industry	Pearson	0.3122*	0.3279*	0.1472*	0.2375*	0.3313*	0.2945*	0.1601*	0.1759	0.2455*	0.3726*
	Spearman	0.5094*	0.4259*	0.6086*	0.4287*	0.6388*	0.5754*	0.438*	0.3206*	0.5456*	0.5042*
	Share of Numbers	29.4%		31.9%		22.2%		24.2%		27.7%	
	Share of Output	85.7%		90.0%		93.0%		91.6%		94.9%	
3. Labor-intensive Industry	Pearson	0.2450*	0.1900*	0.2803*	0.2776*	0.1853*	0.4638*	0.1173*	0.1454	0.1976*	0.2938*
	Spearman	0.4631*	0.3657*	0.6983*	0.5644*	0.6191*	0.5714*	0.5641*	0.2716*	0.6951*	0.4544*
	Share of Numbers	17.5%		14.1%		10.3%		13.6%		11.9%	
	Share of Output	47.9%		47.5%		37.4%		41.8%		40.4%	
4. Metal and Chemical Industry	Pearson	0.2740*	0.3237*	0.2515*	0.3686*	0.3436*	0.3792*	0.2257*	0.0936	0.2644*	0.3195*
	Spearman	0.5362*	0.5665*	0.6792*	0.6949*	0.6885*	0.6279*	0.5168*	0.4012*	0.6867*	0.6272*
	Share of Numbers	17.4%		15.9%		13.5%		11.3%		13.8%	
	Share of Output	47.6%		48.5%		66.6%		45.3%		48.8%	

Notes: * represents 0.1 per cent statistical significance in Pearson correlation and Spearman rank correlation tests.

Sources: Industrial Surveys (1999, 2000, 2001, 2003), National Statistical Office, Thailand.

Table 4: Summary statistics of variables

Variable	Resource-based Industry		Machinery Industry		Labor-intensive Industry		Metal and Chemical Industry	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Labor Productivity	0.41710	2.32263	0.49450	1.79706	0.22868	0.73207	0.62631	4.28512
Foreign Presence 3-digit	0.35265	0.15934	0.73711	0.24940	0.41617	0.18499	0.48435	0.19659
Foreign Presence 4-digit	0.33735	0.21461	0.72085	0.28194	0.40967	0.19438	0.47148	0.23105
Demand Linkage 3-digit	6.28951	2.91091	13.31524	4.88158	6.92158	3.28553	8.70867	3.73795
Demand Linkage 4-digit	5.72138	3.79341	12.61730	5.19825	6.74590	3.27704	8.13370	4.25056
Capital-Labor Ratio	0.85656	3.24417	0.81646	2.31065	0.37119	1.41922	1.12976	4.32602
Plant Size	98.621	270.574	192.917	574.000	147.798	393.496	70.594	159.601
Plant Age	12.84157	10.6334	11.11999	8.92147	10.74385	9.32393	12.37242	10.10208
Export	0.21625	0.41170	0.34876	0.47663	0.37001	0.48284	0.20164	0.40126
Import	0.22328	0.41646	0.55589	0.49692	0.36941	0.48268	0.42607	0.49454
Protection 4-digit	0.22251	0.18981	0.14916	0.11001	0.24651	0.30617	0.16058	0.07925
Output	212.11	1889.90	577.35	3435.59	114.18	429.50	219.38	1329.16
Value-added	64.10	662.65	155.83	1037.82	35.45	131.18	62.02	541.78

Table 5: Spillover effect and plant productivity

	Resource-based Industry				Machinery Industry				Labor-intensive Industry				Metal and Chemical Industry			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Foreign Presence 3-digit	-0.1963**	-0.1978**			0.2558**	0.2343*			-0.1992	-0.1796			-0.1159	-0.1774		
	(0.0940)	(0.0939)			(0.1305)	(0.1308)			(0.1228)	(0.1299)			(0.1209)	(0.1228)		
Foreign Presence 4-digit			0.0637	-0.0764			0.2577***	0.203*			-0.1685	-0.0581			-0.015	-0.0465
			(0.0559)	(0.0626)			(0.0980)	(0.1248)			(0.1042)	(0.1191)			(0.0808)	(0.1055)
Capital-Labor Ratio	0.4496***	0.4259***	0.4492***	0.4259***	0.2352***	0.2313***	0.2351***	0.2315***	0.4022***	0.3993***	0.4018***	0.3990***	0.3165***	0.3132***	0.3168***	0.3137***
	(0.0068)	(0.0069)	(0.0068)	(0.0069)	(0.0128)	(0.0129)	(0.0128)	(0.0129)	(0.0093)	(0.0093)	(0.0093)	(0.0093)	(0.0101)	(0.0102)	(0.0101)	(0.0102)
Plant Size	0.1267***	0.1032***	0.1281***	0.1036***	0.0746***	0.0759***	0.0743***	0.0761***	-0.0258**	-0.0235*	-0.0261**	-0.0234*	0.1202***	0.1213***	0.1203***	0.1214***
	(0.0098)	(0.0098)	(0.0098)	(0.0098)	(0.0171)	(0.0171)	(0.0171)	(0.0171)	(0.0126)	(0.0126)	(0.0126)	(0.0126)	(0.0141)	(0.0143)	(0.0142)	(0.0143)
Plant Age	0.1485***	0.1479***	0.1472***	0.1489***	0.2621***	0.2506***	0.2549***	0.2494***	0.4022***	0.3878***	0.4006***	0.3870***	0.3917***	0.3912***	0.3928***	0.3919***
	(0.0497)	(0.0492)	(0.0498)	(0.0493)	(0.0891)	(0.0891)	(0.0890)	(0.0891)	(0.0642)	(0.0641)	(0.0642)	(0.0641)	(0.0705)	(0.0706)	(0.0706)	(0.0706)
Age-squared	-0.0076	-0.0049	-0.0073	-0.0051	-0.0559***	-0.0518**	-0.0540***	-0.0517**	-0.0758***	-0.0708***	-0.0752***	-0.0707***	-0.072***	-0.0729***	-0.0722***	-0.0730***
	(0.0113)	(0.0112)	(0.0113)	(0.0112)	(0.0208)	(0.0208)	(0.0208)	(0.0208)	(0.0154)	(0.0154)	(0.0154)	(0.0154)	(0.0160)	(0.0160)	(0.0160)	(0.0160)
Export	0.2049***	0.2978***	0.2035***	0.2976***	0.0645	0.0561	0.0633	0.0558	0.3538***	0.3731***	0.3554***	0.3756***	0.1816***	0.1978***	0.1808***	0.1977***
	(0.0330)	(0.0334)	(0.0330)	(0.0334)	(0.0537)	(0.0540)	(0.0537)	(0.0540)	(0.0388)	(0.0388)	(0.0387)	(0.0388)	(0.0462)	(0.0464)	(0.0462)	(0.0464)
Import	0.2034***	0.1655***	0.2023***	0.1662***	0.2187***	0.2208***	0.2179***	0.2207***	0.2716***	0.2358***	0.2706***	0.2356***	0.2545***	0.2549***	0.2550***	0.2555***
	(0.0291)	(0.0293)	(0.0291)	(0.0293)	(0.0400)	(0.0401)	(0.0400)	(0.0401)	(0.0364)	(0.0366)	(0.0364)	(0.0366)	(0.0331)	(0.0333)	(0.0331)	(0.0333)
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Effects 3-digit	Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes	
Industry Effects 4-digit		Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes
N obsevations	14355	14355	14355	14355	3577	3577	3577	3577	7144	7144	7144	7144	6279	6279	6279	6279
R-squared	0.3297	0.3285	0.3304	0.3286	0.1667	0.1660	0.1688	0.1678	0.3117	0.3114	0.2942	0.3108	0.2286	0.2290	0.2275	0.2277

Notes: Dependent variable is labor productivity of plant. Standard errors are in the parentheses. ***, **, * indicate 1 per cent, 5 per cent, 10 per cent statistical significance, respectively.

Table 6: Demand linkage effect and plant productivity

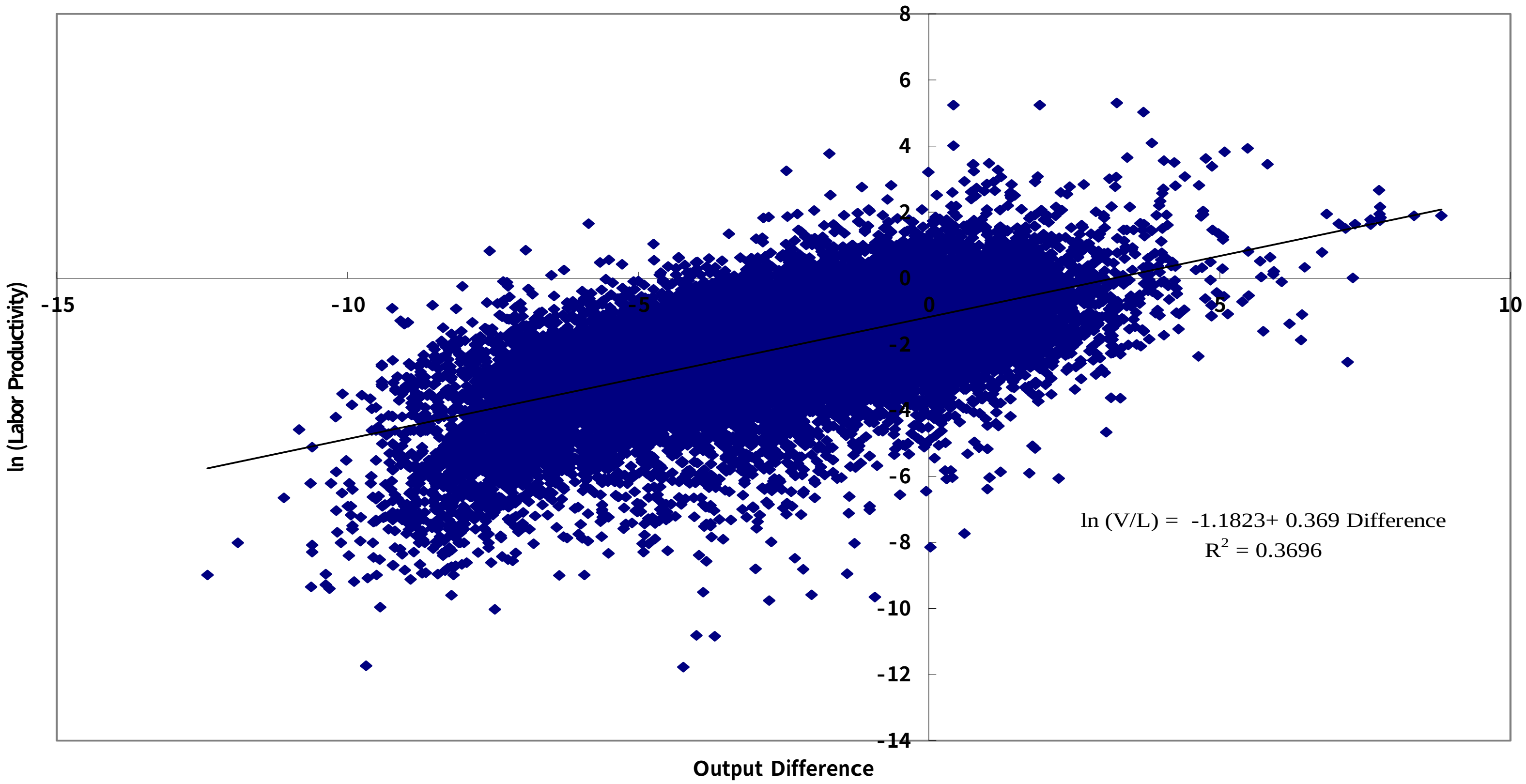
	Resource-based Industry				Machinery Industry				Labor-intensive Industry				Metal and Chemical Industry			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Demand Linkage 3-digit	-0.011**	-0.0113**			0.0156*	0.0143*			-0.0111	-0.0010			-0.0084	-0.0119*		
	(0.0053)	(0.0053)			(0.0080)	(0.0080)			(0.0073)	(0.0078)			(0.0069)	(0.0070)		
Demand Linkage 4-digit			0.0041	-0.0051			0.0137**	0.0105			-0.0103*	-0.0052			0.0005	-0.0035
			(0.0032)	(0.0037)			(0.0056)	(0.0072)			(0.0062)	(0.0071)			(0.0044)	(0.0059)
Capital-Labor Ratio	0.4496***	0.4259***	0.4491***	0.4259***	0.2352***	0.2313***	0.2348***	0.2312***	0.4021***	0.3992***	0.4019***	0.3991***	0.3163***	0.3130***	0.3169***	0.3136***
	(0.0068)	(0.0069)	(0.0068)	(0.0069)	(0.0128)	(0.0128)	(0.0128)	(0.0129)	(0.0093)	(0.0093)	(0.0093)	(0.0093)	(0.0101)	(0.0102)	(0.0101)	(0.0102)
Plant Size	0.1266***	0.1032***	0.1281***	0.1035***	0.0746***	0.0758***	0.0745***	0.0762***	-0.0258**	-0.0235*	-0.0261**	-0.0234*	0.1201**	0.1213***	0.1204***	0.1214***
	(0.0098)	(0.0098)	(0.0098)	(0.0098)	(0.0171)	(0.0171)	(0.0171)	(0.0171)	(0.0126)	(0.0126)	(0.0126)	(0.0126)	(0.0141)	(0.0143)	(0.0142)	(0.0143)
Plant Age	0.1485***	0.1479***	0.1472***	0.1489***	0.2620***	0.2506***	0.2536***	0.2477***	0.4022***	0.3879***	0.4007***	0.3872***	0.3916***	0.3913***	0.3921***	0.3922***
	(0.0497)	(0.0492)	(0.0498)	(0.0493)	(0.0891)	(0.0891)	(0.0890)	(0.0891)	(0.0642)	(0.0641)	(0.0642)	(0.0641)	(0.0705)	(0.0706)	(0.0706)	(0.0706)
Age-squared	-0.0076	-0.0049	(0.0073)	-0.0051	-0.0559***	-0.0518**	-0.0537***	-0.0512**	-0.0757***	-0.0708***	-0.0753***	-0.0707***	-0.0720***	-0.0730***	-0.0720***	-0.0731***
	(0.0113)	(0.0112)	(0.0113)	(0.0112)	(0.0208)	(0.0208)	(0.0208)	(0.0208)	(0.0154)	(0.0154)	(0.0154)	(0.0154)	(0.0160)	(0.0160)	(0.0160)	(0.0160)
Export	0.2048***	0.2977***	0.2039***	0.2976***	0.0647	0.0562	0.0638	0.0559	0.3541***	0.3734***	0.3549***	0.3751***	0.1818***	0.1978***	0.1813***	0.1978***
	(0.0330)	(0.0334)	(0.0330)	(0.0334)	(0.0537)	(0.0540)	(0.0537)	(0.0540)	(0.0388)	(0.0388)	(0.0388)	(0.0387)	(0.0462)	(0.0464)	(0.0462)	(0.0464)
Import	0.2034***	0.1655***	0.2021***	0.1662***	0.2188***	0.2209***	0.2172***	0.2201***	0.2716***	0.2358***	0.2712***	0.2355***	0.2544***	0.2547***	0.2550***	0.2554***
	(0.0291)	(0.0293)	(0.0291)	(0.0293)	(0.0400)	(0.0401)	(0.0400)	(0.0401)	(0.0364)	(0.0366)	(0.0364)	(0.0366)	(0.0331)	(0.0333)	(0.0331)	(0.0333)
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Effects 3-digit	Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes	
Industry Effects 4-digit		Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes
N observations	14355	14355	14355	14355	3577	3577	3577	3577	7144	7144	7144	7144	6279	6279	6279	6279
R-squared	0.3299	0.3287	0.3305	0.3284	0.1667	0.1661	0.1685	0.1674	0.3114	0.3112	0.3114	0.3109	0.2295	0.2299	0.2271	0.2279

Notes: Dependent variable is labor productivity of plant. Standard errors are in the parentheses. ***, **, * indicate 1 per cent, 5 per cent, 10 per cent statistical significance, respectively.

Table 7: Averages of variables by ownership

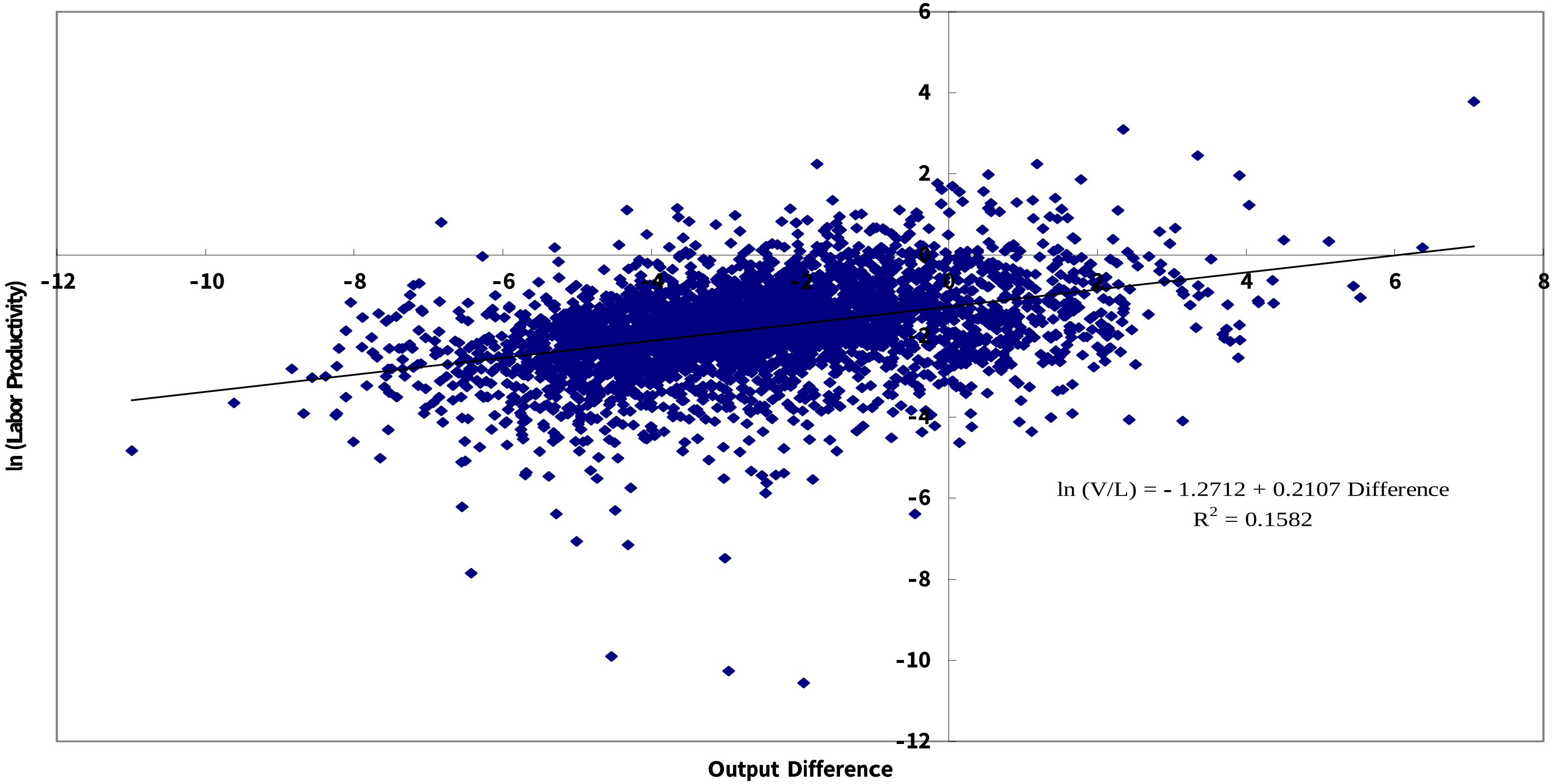
Variable	Resource-based Industry			Machinery Industry			Labor-intensive Industry			Metal and Chemical Industry		
	Local	Foreign	Ratio	Local	Foreign	Ratio	Local	Foreign	Ratio	Local	Foreign	Ratio
Labor Productivity	0.36074	0.98015	2.717	0.32593	0.92097	2.826	0.20691	0.35554	1.718	0.46460	1.51697	3.265
	(2.1620)	(3.4999)		(0.9889)	(2.9458)		(0.7478)	(0.6177)		(4.0918)	(5.1349)	
Capital-Labor Ratio	0.7471	1.9501	2.610	0.5650	1.40892	2.494	0.3307	0.6071	1.836	0.7672	3.1268	4.076
	(2.4081)	(7.5135)		(2.0504)	(2.8285)		(1.1003)	(2.5760)		(2.9029)	(8.4093)	
Plant Size	76.230	322.291	4.228	68.727	507.197	7.380	115.758	334.498	2.890	56.026	150.833	2.692
	(205.743)	(571.713)		(150.174)	(984.273)		(290.608)	(724.237)		(118.142)	(285.218)	
Plant Age	12.85	12.75	0.992	11.62	9.85	0.848	10.74	10.74	0.999	12.48	11.78	0.944
	(10.5558)	(11.3826)		(8.9894)	(8.6217)		(9.4784)	(8.3707)		(10.1259)	(9.9534)	
Export	0.16238	0.75435	4.646	0.16271	0.81908	5.034	0.29017	0.83524	2.878	0.12709	0.61228	4.818
	(0.3688)	(0.4306)		(0.3691)	(0.3851)		(0.4539)	(0.3711)		(0.3331)	(0.4874)	
Import	0.18070	0.64857	3.589	0.41851	0.90318	2.158	0.29717	0.79038	2.660	0.35913	0.79474	2.213
	(0.3848)	(0.4776)		(0.4934)	(0.2958)		(0.4570)	(0.4072)		(0.4798)	(0.4041)	
Output	138.00	952.40	6.901	88.06	1815.51	20.616	73.63	350.50	4.760	134.80	685.22	5.083
	(1263.12)	(4767.10)		(461.07)	(6244.02)		(257.68)	(898.68)		(1068.81)	(2225.48)	
Value-added	45.75	247.35	5.406	27.32	481.05	17.611	24.05	101.92	4.238	39.57	185.67	4.693
	(625.15)	(940.81)		(112.85)	(1903.19)		(91.95)	(251.16)		(515.40)	(655.30)	
N observation	14355	1437	0.100	3577	1414	0.395	7144	1226	0.172	6279	1140	0.182

Figure 1: Output difference and labor productivity (all local plants except for machinery)



Sources: Industrial Surveys (1999, 2000, 2001, 2003), National Statistical Office, Thailand.

Figure 2: Output difference and labor productivity (local machinery plants)



Sources: Industrial Surveys (1999, 2000, 2001, 2003), National Statistical Office, Thailand.

Table 8: Output difference and plant productivity

	Total Sample		Resource-based		Machinery		Labor-intensive		Matal and Chemical	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Output Difference	0.2443***	0.2551***	0.2747***	0.2729***	0.2029***	0.2411***	0.1789***	0.1828***	0.2828***	0.3367***
	(0.0048)	(0.0049)	(0.0071)	(0.0073)	(0.0141)	(0.0149)	(0.0109)	(0.0109)	(0.0102)	(0.0109)
Square of Difference	-0.0236***	-0.0229***	-0.0196***	-0.0205***	-0.008***	-0.0038***	-0.044***	-0.0437***	-0.0196***	-0.0145***
	(0.0008)	(0.0008)	(0.0010)	(0.0010)	(0.0026)	(0.0027)	(0.0018)	(0.0018)	(0.0019)	(0.0019)
YearEffects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Effects 3-digit	Yes		Yes		Yes		Yes		Yes	
Industry Effects 4-digit		Yes		Yes		Yes		Yes		Yes
N observations	31738	31738	14489	14489	3612	3612	7226	7226	6335	6335
R-squared	0.3709	0.3707	0.4072	0.4073	0.1856	0.1835	0.4461	0.4460	0.3631	0.3629

Notes: Dependent variable is labor productivity of plant. Standard errors are in the parentheses.
*** indicates statistical significance at 1 per cent.

Table 9: Trade liberalization and plant productivity

	Total Sample		Resource-based		Machinery		Labor-intensive		Matal and Chemical	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Protection 4-digit	-0.2821***	-0.0556	0.1297	0.4235***	-0.4915*	-0.7306***	-0.6027***	-0.5159***	0.2310	1.1048***
	(0.0570)	(0.0855)	(0.0948)	(0.1328)	(0.2515)	(0.2667)	(0.0837)	(0.1500)	(0.2997)	(0.3991)
YearEffects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Effects 3-digit	Yes		Yes		Yes		Yes		Yes	
Industry Effects 4-digit		Yes		Yes		Yes		Yes		Yes
N observations	31738	31738	14489	14489	3612	3612	7226	7226	6335	6335
R-squared	0.0420	0.0398	0.0353	0.0322	0.0549	0.0557	0.0715	0.0720	0.0333	0.0359

Notes: Dependent variable is labor productivity of plant. Standard errors are in the parentheses.
***, * indicate statistical significance at 1 per cent and 10 per cent respectively.

Table 10: ISIC Industry Codes (Rev. 3)

2 digit	Division of Industry
15	Manufacture of food products and beverages
16	Manufacture of tobacco products
17	Manufacture of textiles
18	Manufacture of wearing apparel dressing and
19	Tanning and dressing of leather manufacture of
20	Manufacture of wood and of products of wood
21	Manufacture of paper and paper products
22	Publishing, printing and reproduction of recorded
23	Manufacture of coke, refined petroleum products
24	Manufacture of chemicals and chemical products
25	Manufacture of rubber and plastic products
26	Manufacture of other non-metallic mineral
27	Manufacture of basic metals
28	Manufacture of fabricated metal products, except
29	Manufacture of machinery and equipment n.e.c.
30	Manufacture of office, accounting and computing
31	Manufacture of electrical machinery and
32	Manufacture of radio, television and
33	Manufacture of medical, precision and optical
34	Manufacture of motor vehicles, trailers and
35	Manufacture of other transport equipment
36	Manufacture of furniture manufacturing n.e.c.