How Do FDIs Affect Performance at Home?: Activity-level Analysis for Japanese Electronics Firms

Toshiyuki MATSUURA [*] [§]
The Institute of Economic Research, Hitotsubashi University, Japan
The Research Institute of Economy, Trade and Industry, Japan

Kazuyuki MOTOHASHI
Department of Technology Management for Innovation School of Engineering,
The University of Tokyo, Japan
The Research Institute of Economy, Trade and Industry, Japan

Kazunobu HAYAKAWA
Inter-Disciplinary Studies Center, Institute of Developing Economies, Japan
The Research Institute of Economy, Trade and Industry, Japan

Abstract: This paper investigates the impacts of FDIs on home productivity by using firms' activity-level data for Japanese electronics firms, instead of firm-level data in past literature. The Vertical FDI (VFDI) firms' change in their main activity at home between pre-investing and post-investing makes the comparison of productivity between them qualitatively difficult because such a change implies the change of firms' home production function per se. The use of activity-level data enables us to avoid influence of the activity change in the evaluation of VFDI's impacts. Our empirical results are consistent with theoretical predictions: Horizontal FDI of an activity does not necessarily have positive significant impacts on productivity in domestic activities same with the invested activity. On the other hand, the VFDI of an activity enhances the productivity significantly in domestic activities with input-output relationship with the invested activity.

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[*] Corresponding author. Toshiyuki Matsuura, Address: The Institute of Economic Research, Hitotsubashi University, 2-1 Naka, Kunitachi, Tokyo 186-8603 Japan. Phone: 81-42-580-8369; Fax: 81-42-580-8333. E-mail: matsuura@ier.hit-u.ac.jp

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1. Introduction

The impacts of Japanese multinational firms' active advance into East Asian countries on their performance at home have received a great deal of attention. Japanese machinery firms have strewed their affiliates in East Asia and have formed international production/distribution networks. The present international production networks are fairly distinctive and most developed, in terms of the significance in each economy, the extensiveness of country coverage, and the sophistication in their structure consisting of both intra-firm and arm's-length transactions. However, such formation of international production networks has forced Japanese firms to specialize in specific production processes such as upstream process at home and thus to shut down domestic plants of the relocated processes. In particular, the latter effect attracts much public attention as hollowing out of domestic industry. Around 2000, accompanied with acceleration of Japanese firms' going to China, its fear reached a peak in Japan.

There is a substantial body of empirical work analyzing if foreign direct investment (FDI) enhances firm performance at home: Navaretti et al. (2004, 2006) for Italian case; Hijzen et al. (2007) and Ito (2007) for Japanese case; Hijzen et al. (2006) and Navaretti et al. (2006) for French case. In such works, the endogeneity of the productivity and FDI must be tackled. That is, since FDI firms by their nature have higher productivity as found in the previous studies such as Kimura and Kiyota (2006), it is ambiguous that higher productivity of FDI firms is attributed to investing (learning effects) or to original higher productivity (selection effects). To tackle such endogeneity, two approaches are adopted in the literature: instrumental variable method and propensity score matching method. In particular, availability of firm-level data encourages the latter method, which requires enough observations compared with the former method.

However, the recent studies have not necessarily succeeded in detecting productivity enhancement of FDI firms at home. Hijzen et al. (2007), which analyze the impacts in the case of Japanese FDI at firm-level, do not detect the robust productivity improvement. Hijzen et al. (2006) and Navaretti et al. (2006) examine such enhancement according to a type of FDI, i.e. Vertical FDI (VFDI) and Horizontal FDI (HFDI). From the theoretical point of view, the resulting impact of HFDI on productivity at home is ambiguous. Its positive impact comes from excellent knowledge or technology in host countries enabling investing firms to produce their products at home more efficiently. The resulting impact of HFDI becomes positive if this positive impact is larger than the negative impact due to the loss of scale economy. On the other hand, the impact of VFDI should be positive due to the vertical division of labor with host countries. The VFDI firms relocate abroad the activity without comparative advantages and thus to specialize their home activity in that with them. Navaretti et al. (2006) classify FDI to developing countries and that to developed countries as VFDI and HFDI, respectively. In Hijzen et al. (2006), VFDI is defined as investments by firms in comparative disadvantage industries to developing countries, while HFDI as those by firms in comparative advantage industries to developed countries. Both Navaretti et al. (2006) and Hijzen et al. (2006) find positively significant enhancement of productivity in French HFDI, but do not in its VFDI, employing firm-level data.

The aim of this paper is to re-examine the impacts of FDI on productivity at home by employing data on Japanese machinery FDI. Particularly in contrast to the

previous studies relying on firm-level data, this paper examines them at firms' activity-level data, not ready-made firm-level data. For example, if a firm has more than one activity such as upstream activity and downstream activity, we treat these activities as different observations. An important difference between the two FDIs is whether investors' main product/activity at home changes or not before and after investing. Different from the HFDI, the VFDI firms change their main activity at home, for example, from downstream activity to upstream activity. Since such an activity change implies the change of firms' home production function *per se*, it is not a valid evaluation to compare *firms*' productivity before and after the VFDI. This means that firm-level analysis in all the previous studies does not present an appropriate picture of the VFDI's impacts. In contrast, the use of firms' activity-level data enables us to compare productivity in an activity before and after investing and thus to avoid influence of the activity change in the evaluation of FDI's impacts. In order to claim the importance of such an analytical unit in their evaluation, we have also conducted a sensitivity analysis of data unit, by estimating the same model for firm-level data. It is found that the choice of the data unit makes a significant difference in the results of FDI's impacts.

The rest of this paper is organized as follows. The next section reviews impact of HFDI and VFDI on productivity at home, and section 3 outlines our empirical methodology. In section 4, we provide our empirical results, and section 5 concludes.

2. Horizontal FDI and Vertical FDI

This section reviews the impact of FDI on domestic plants' performance. First, we set our conceptual framework of FDIs. Next, we discuss conditions for the dominance of each FDI and then its impacts on productivity at home.

In the FDI literature, there are mainly two kinds of investments: HFDI and VFDI. The HFDI is a strategy to avoid broadly-defined trade costs by setting up plants within the targeting market/country rather than by exporting from the home country. Thus, the HFDI firms locate the basically same production activity in both home and host countries. On the other hand, the VFDI is one to exploit low price-production factors of the host country. In the VFDI, firms completely relocate a part of production processes to the host country. The relocated processes are ones that intensively use the production factors of which prices are lower in the host country. As a result, at least from the theoretical point of view, production activities located in the host country exist also in the home country in the case of the HFDI but do not in the case of the VFDI. In addition, there is a difference in sales destination between HFDI and VFDI. The sales destination of affiliates is basically their host country in HFDI and other countries in VFDI. Although the MNEs' motivation of investing abroad is diversified in the real world and thus all the affiliates cannot be necessarily classified into either VFDI or HFDI, this classification would be still useful to analyze the MNEs' behavior.

There are clear conditions for the dominance of each FDI. In the HFDI, suppose that there is a country (host country) with the same level of factor prices as home. We assume increasing returns to scale technology and broadly-defined trade costs for shipment of products between countries. Firms can supply their products to the country by either means; exporting from home or locating production plants within the host country. They choose the means with higher total profit, which is sum

of gross profits gotten by selling for home and abroad. The exporting enables to save fixed costs to set up production plants abroad, while the HFDI to save shipment costs. Therefore, they perform HFDI if the fixed costs are low enough and the shipment costs are high enough.

On the other hand, in the VFDI, suppose a country (host country) with location advantages in producing downstream products and a firm selling final products around the world. The firm establishes two kinds of plants at home or abroad, i.e. a plant producing downstream products and a plant producing upstream products. Products in *each* production process are produced with increasing returns to scale technology. It is necessary to incur broadly-defined trade costs for shipment of products between countries. We here focus on the VFDI that the firm tries to relocate a downstream plant to the country. The firm decides to relocate it if the joint profit for an upstream plant at home and a downstream plant abroad exceeds the profit for the integrated production at home. The integrated production at home enables firms to save shipment costs to transport upstream products from home to abroad, while the VFDI can lead to a reduction of the costs of primary production factors due to enjoying location advantages differentials. Therefore, firms perform VFDI if shipment costs are low enough and such differentials are large enough.

The sources of the impact of investing on productivity of home plants are qualitatively different between HFDI and VFDI. The HFDI changes home plant's average cost through the following channels. The quantity of production in the home plant unambiguously decreases because it stops producing goods designed for the host country.[1] This decrease obviously raises the average cost as depicted in Figure 1, where X_{pre} and X_{post} are the quantities of home production before and after investing, respectively. In this case, the home plant's productivity definitely decreases.[2] However, there may be knowledge or technology spillover from the abroad plant to the home plant as pointed out in the previous studies, e.g. Navaretti et al. (2006). If such spillover effects exist and the home plant enjoys an enough decrease of marginal cost, the average cost declines as depicted in Figure 2. In sum, the impact of HFDI on home plant's productivity depends on the existence and magnitude of knowledge/technology spillover from host countries.

=== Figures 1-2 ===

On the other hand, the impact of VFDI at home is less ambiguous than that of HFDI. We restrict our attention only to the cost structure of an upstream plant at home. The VFDI affects its average cost through two kinds of changes in its production quantity of upstream products. The one is a decrease of the quantity because firms need to incur the expenses for transportation of upstream products from home country to the host country. The other is an increase of the production quantity of upstream products because the save of costs for primary production factors in the firm decreases the price of final products. The decrease of final products' price increases their production quantity and thus also the production

[1] As mentioned just above, firms perform HFDI when shipment costs are high enough. Thus, the HFDI increases the production quantity of products for the (host) country's market because firms are no longer necessary to incur such high shipment costs.

[2] The home plant's fixed cost rises if the home plant pays a part of the fixed cost to establish a plant abroad. Then, the home plant's productivity decreases more.

quantity of upstream products. As mentioned above, because firms perform VFDI if shipment costs are low enough and the save of costs for primary production factors are large enough, the net impact of the production quantity of upstream products becomes positive.[3] As a result, the average cost of home upstream plant decreases as depicted in Figure 3, and thus its productivity rises.

=== Figure 3 ===

We examined so far the impact of FDIs on the *level* of productivity at home plants. Indeed, almost all the previous studies have empirically investigated the impact on its level. However, FDIs might also affect the *growth* of productivity. On the one hand, in HFDI, knowledge/technological spillover gives influence on the *growth* of productivity. There are a large number of studies analyzing various kinds of spillover effects. For instance, the impact of MNEs' presence on indigenous firms' productivity has been examined (see, for example, Gorg and Greenaway, 2004; Crespo and Fontoura, 2007). In the literature, most of the papers found its positive impact on the growth of their productivity. Since the main source of positive impact of HFDI is also knowledge/technological spillover, HFDI might affect not only the level but also the growth of productivity at home. On the other hand, in VFDI, Hijzen et al. (2008) pointed out the possibility of impacts of offshoring on the growth of productivity. The impacts of VFDI and offshoring are considered to be basically the same. Hijzen et al. (2008) claimed that specializing in skill-intensive production stages through offshoring generates higher growth in productivity due to larger learning-by-doing effects than in the case of no offshoring. Consequently, both HFDI and VFDI might affect not only the level but also the growth of productivity in plants at home. Thus, from the next section, we empirically investigate impact on both level and growth of productivity at home, applying to the Japanese FDIs.

3. Empirical Issues

In this section, we first explain our empirical methodology to examine the impact of FDIs on performance at home. Next we list our data sources and simply explain how to construct our productivity measure.

3.1. Empirical Methodology

This paper investigates the impact of FDIs on home productivity at detail level. Our analytical unit is production activities of specific line of business, instead of firm. In the previous section, we mentioned that a part of the activities is completely relocated from home to abroad in the VFDI firms. That is, the activities in which they are engaged at home are different before and after investing. Since productivity in an activity is not basically comparable with that in the other activity, the firm-level investigation of VFDI's impacts on productivity becomes empirically vacuity. In other words, the differences in the VFDI firms' productivity between pre-investing and post-investing consist of not only learning effects but also various elements attributed to their activity change. To extract only the learning effects, we need to

[3] To show this conjecture, we need a formal model incorporating MNEs' decision on investing. See, for example, Navaretti and Venables (2004).

focus on the productivity change only in the domestically-remained part of activities before and after investing. To do that, we employ data at not firm-level but firms' activity-level.

Such high disaggregation of analytical level prevents us from employing matching method, which is often done in the previous studies listed in the introductory section. The use of this method is aimed to tackle the endogeneity problem; investors by their nature have higher productivity than non-investors, i.e. selection effects. The (nearest) matching method usually chooses a not-investing firm not only with the closest probability of investment but also in the same industry as an investing firm. However, our high disaggregation implies that the potential number of firms in the same industry/production process as investing firms becomes small even if our dataset is one of the largest datasets available in Japan. Thus, lack of enough observations prevented us from reaching a good matching. As a result, this paper conducts regression analysis.

Following Castellani et al. (2007) and Hijzen et al. (2008), we specify a linear equation with a lagged dependent variable in order to control fluctuation by the elements not adequately measured by our productivity index. In this paper, we estimate two kinds of equations at firm's activity-level: level equation and growth equation. The equations at firm's activity-level are as follows:

$$TFP_{ij}(t) = \rho\, TFP_{ij}(t\text{-}1) + \beta_1 Horizontal_{ij}(t\text{-}1) + \beta_2 Vertical_{ij}(t\text{-}1) + \delta(t) + \eta_{ij} + \varepsilon_{ij}(t),$$

$$\Delta TFP_{ij}(t) = \lambda\, \Delta TFP_{ij}(t\text{-}1) + \gamma_1 Horizontal_{ij}(t\text{-}1) + \gamma_2 Vertical_{ij}(t\text{-}1) + \delta(t) + \eta_{ij} + \varepsilon_{ij}(t),$$

where TFP_{ij} (t) and ΔTFP_{ij} (t) denote the level of and the first-difference of productivity in firm i's activity j in year t, respectively. We employ total factor productivity index as productivity measure, and its way of construction is explained later. $Horizontal_{ij}$ and $Vertical_{ij}$ represent the magnitude of firm i's activity j's HFDI and VFDI, respectively. We take the lagged dependent variable and the two FDI variables as predetermined. To control for the endogeneity of those predetermined variables, we employ the System GMM (general method of moments) proposed by Blundell and Bond (1998). We use the second and third lagged observations of the dependent variable and of the FDI variables as instruments. In both equations, the error term is modelled as a time fixed effect (δ), a firm's activity fixed effect (η), and the usual disturbance (ε).

In order to pinpoint the impacts of FDIs on productivity at the related activities, we need to appropriately formulate two FDI variables. As mentioned in section 2.1., HFDI locates foreign plants with the same activity as home, while VFDI locates those with the different activity from home, particularly the activity with the input-output relationship with the home activity. Thus, the measure of the HFDI in a firm i's activity should embody the magnitude of production abroad in that activity. On the other hand, the measure of the VFDI in a firm i's activity should represent the magnitude of production abroad in activities having input-output relationship with the domestically-remained activity. Suppose that an MNE with upstream and downstream activities at home has downstream activities in both East Asia and North America and an upstream activity in North America.[4] Such an example is shown in

[4] In this paper, developed countries include North American countries, Western European countries, Australia, and New Zealand. East Asia includes South Korea, Taiwan, Hong Kong,

Table 1. *A*-*E* represent the magnitude of the corresponding activity. In this setting, for upstream activity at home (*A*), *Horizontal* refers to *C*, while *Vertical* for that is the sum of *D* and *E*.

=== Table 1 ===

Furthermore, we should adjust the scale of the two FDI variables in order to extract unexpected elements. As for the HFDI variable, we divide by the magnitude of firm *i*'s production of the concerned activity in the whole world including home in order to measure relative magnitude of production abroad in an activity concerned. In Table 1, for example, the HFDI variable for upstream activity at home (*A*) is adjusted by the sum of *A* and *C*. On the other hand, as for the VFDI variable, we divide by the magnitude of firm *i*'s production of an industry in the whole world including home. "Industry" means the sum of upstream and downstream activities. That is, in Table 1, the VFDI variable for upstream activity at home (*A*) is adjusted by the sum of *A*, *B*, *C*, *D*, and *E*. The reason why we include the same activity as home activity is to distinguish *plat-form type* VFDI (vertical division of labor between host and the other host countries) from *pure* VFDI (vertical division of labor between home and host countries) to some extent. For instance, in Table 1, if the East Asian downstream plant (*D*) purchases upstream products from not home (*A*) but North America (*C*), the upstream plant at home (*A*) does not enjoy productivity enhancement due to setting up downstream plants at East Asia (*D*). To appropriately evaluate the magnitude of pure VFDI, we divide by the sum of the magnitude of all activities in an industry in the world.

In this paper, magnitude of overseas activities is measured by overseas affiliates' employment. Although data of overseas affiliates' sales is available, the prices are not reported in the Survey. Besides, there is possibility that some perform only cosmetic processing of the goods manufactured by their parents to circumvent trade barriers. The more appropriate variable might be the value added in each overseas affiliate. However, since cost of intermediate input, which is necessary to calculate the value added, is frequently not reported, therefore we used the number of employment as a proxy. As a result, we formalize two FDI variables as the followings:

$$Horizontal_{ij} = \frac{\sum_{r \in R_O} L^r_{ij}}{\sum_{r \in R} L^r_{ij}}, \quad Vertical_{ij} = \frac{\sum_{r \in R_O} \sum_{k \in S_j} L^r_{ik}}{\sum_{j \in S} \sum_{r \in R} L^r_{ij}}.$$

L^r_{ij} represents firm *i*'s activity *j*'s employment in country *r*. *S* denotes a set of all activities in the industry to which activity *j* belongs. *R* is a set of all countries: $R \in$ {Japan, Advanced countries, East Asian countries, Other countries}. $R_O \in$ {Advanced countries, East Asian countries, Other countries}. S_j denotes a set of activities having input-output relationship with activity *j*. For example, if activity *j* is "electrical machinery, equipment and supplies", S_j is "electronic parts and devices". The list of all activities is presented in the next subsection.

Last, two points are noteworthy. First, our variables representing FDIs are continuous ones though most of the previous studies use binary ones, i.e. taking unity

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Singapore, Malaysia, Philippine, Thailand, Indonesia, and China.

if firms conduct FDIs and zero otherwise.[5] Our choice is based on the claim that spillover and division-of-labor benefits from FDIs should gradually start to work. That is, overseas affiliates have not always gotten engaged in full production activity since the time they just entered. But the domestically-remained activities can enjoy such benefits since the time they get engaged in a sufficient level of production activities. To take such a time lag into consideration, we employ the continuous variables representing affiliates' activities. However, employing such continuous variables, we cannot distinguish the impact of the first time FDI from that of the second time FDI if MNEs set up their second affiliate before their first affiliate starts a sufficient level of production activities. Thus, we measure affiliate's activities as activities of *all* affiliates located in the region concerned rather than activities of the first affiliate.[6]

Second, one may worry about the double counting of learning effects. Remember the example presented in Table 1. Our methodology to identify FDI type takes foreign upstream plant (*C*) as HFDI for the home upstream plant (*A*) and as VFDI for the home downstream plant (*B*). That is, the effect of locating a plant abroad shows up in both *Horizontal* and *Vertical* if an MNE has both downstream and upstream plants in home country (integrated MNEs). Such double counting produces unexpected noise in coefficients for both *Horizontal* and *Vertical*. However, since there are few integrated MNEs[7], the influence of such double counting on our estimates would be trivial.

3.2. Data Issues

Our primary data sources are the linked longitudinal data sets of "Census of Manufactures" and "Basic Survey of Overseas Business and Activities" during the period 1981-2003.[8] In the Census of Manufactures, data on establishments locating in Japan (e.g. location, the number of employees, tangible assets, and value of shipments) are available. Those data in Japanese overseas affiliates between 1985 and 2003 are available in the Basic Survey of Overseas Business and Activities. The information on parent firms of establishments/affiliates, e.g. the number of employees, can be obtained from the Basic Survey of Japanese Business Structure and Activities. We exclude plants with less than 9 employees because they do not provide the information on capital, of which data are indispensible for estimating productivity measure, total factor productivity (TFP). Besides, capital data are not available in 2001 and 2002 for plants with less than 29 employees; our linked panel data set is restricted from 1985 to 2000 and 2003.

We estimate the TFP index, following Caves et al. (1982, 1983) and Good et al. (1983). TFP index at firm's activity-level is calculated as:

[5] Hijzen et al. (2008) also use the continuous variables.

[6] There seems to be an important link of FDI's impact on performance with the number of affiliates. However, examining such a link is beyond the scope of this paper.

[7] Indeed, the share of integrated MNEs in all MNEs is around 10%. That is, once firms invest abroad, most of the MNEs are likely to have only one activity.

[8] For the details of data construction, see Appendix A.

$$TFP_{ijt} = \left(\ln Q_{ijt} - \overline{\ln Q_t}\right) - \sum_{f=1}^{F} \frac{1}{2}\left(s_{ijft} + \overline{s_{ft}}\right)\left(\ln X_{ijft} + \overline{\ln X_{ft}}\right)$$
$$+ \sum_{s=1}^{t}\left(\overline{\ln Q_s} - \overline{\ln Q_{s-t}}\right) - \sum_{s=1}^{t}\sum_{f=1}^{F} \frac{1}{2}\left(\overline{s_{fs}} + \overline{s_{fs-1}}\right)\left(\overline{\ln X_{fs}} - \overline{\ln X_{fs-1}}\right) \quad ,$$

where Q_{ijt}, s_{ijft} and X_{ijft} denote the gross output of firm *i*'s *activity j* in year *t*, the cost share of input *f* for firm's *activity j* in year *t*, and input of factor *f* in firm's *activity j* in year *t*, respectively. Variables with an upper bar denote the industry average of that variable. We define a hypothetical (representative) firm for each year by industry. Its input and output are calculated as geometric means of those of all firms in certain industry. The first two terms on the right hand side of equation denote the cross-sectional TFP index based on the Thiel = Tornqvist specification for each firm, for each year, relative to a hypothetical firm. Since this cross-sectional TFP index is not comparable between *t* and *t*-1, we adjust the cross sectional TFP index with the growth rate of TFP for a hypothetical firm as in the third and fourth term in the equation. For more details on each variable, see Appendix B.

This paper focuses on five activities in the electronics and machinery manufacturing industry, in which we can observe the most outstanding overseas activities during our sample period. Four of them are categorized in downstream activities, and one of them is in upstream activity. Such classification of upstream or downstream is based on the input-output relationship among them, which is explored by employing the Input-Output Tables (Ministry of Internal Affaire and Communications of Japan). First, we define upstream activities as ones in which a share of manufactures' intermediate demand in total domestic demand is greater than around 90%. Such an activity in the electronics and machinery industry is "electronic parts and devices". Next, downstream activities of the upstream activity are defined as ones in which a share of the upstream activity in total inputs is greater than 10%. As a result, the downstream activities of "electronic parts and devices" are "electronic equipment", "electronic data processing machines", and "communication equipment".

Table 2 shows the number of firms in 2000 by combination between home activity and abroad activity. For example, a number "113" indicates that there are 113 firms both with downstream activities at home and with upstream activities abroad. The numbers of firms with activities concerned only in East Asia are in parentheses. This table tells us three points. First, there are a lot of firms with the same activity between home and abroad, compared with the firms with the different activities between them. From our methodological point of view, this might indicate that there are more HFDI firms than VFDI ones. Second, the ratio of HFDI firms to VFDI firms is almost the same level between downstream (174/113) and upstream activities (124/81) at home. This implies that there are as many VFDIs of upstream activities as VFDIs of downstream activities. Third, as well known, most of the Japanese FDIs are directed for East Asia. Thus, the above two points hold also for Japanese FDIs to East Asia.

=== Table 2 ===

The second fact might contradict with our presumption that Japanese firms move labor intensive-downstream activities to overseas, while they keep capital intensive-upstream ones inside Japan. But, production process-wise vertical division

of labor in Japanese MNEs might be more complicated than such presumption. The upper area in Table 3 shows the average of shares of affiliates' imports from Japan in their total procurements.[9] We can see that upstream affiliates have outstandingly high shares, even compared with downstream ones. For example, while the share of imports from Japan for communication equipment, one of downstream activities, is around 30% to 40%, that for semiconductor exceeds 60%. Furthermore, the downer area in the table shows the average of shares of affiliates' exports to Japan in their total sales, indicating that the upstream affiliates, particularly in ASEAN and China, are more likely to export their products to Japan than the downstream affiliates. In case of semiconductor manufacturing affiliates in ASEAN and China, more than 60% of their products are exported to Japan. Since around 90% of affiliates' exports to Japan are intra-firm trade,[10] such upstream products will be further assembled in home plants, and the assembled products might be again exported abroad. This pattern comes from the complex nature of production system in electronics industry. For example, manufacturing process of semiconductor can be decomposed into two parts, capital-intensive parts such as lithography and etching and labor-intensive parts such as packaging and inspection. A large portion of the latter labor-intensive parts is conducted in China, and the completed semiconductor products are imported back to Japan to be used for further assembling electronics products. Due to such a complex nature in electronics industry, we may find positive impact of VFDI not only in upstream activities but also in downstream activities.

=== Table 3 ===

4. Empirical Results

This section reports our estimation results. The estimation of some other equations is also performed. Basic statistics of our variables are presented in Table 4.

=== Table 4 ===

The system GMM regression results are reported in Table 5. Introducing only the first-lagged dependent variable in the level equation, we can see that the results of AR(2) test and Hansen's *J* test are disappointingly rejected and are not consistent with the assumption of System GMM. Based on the rejection of AR(2) test, we introduce both the second and third lagged dependent variables as independent variables in the level equation. The results are as follows. First, the coefficients for *Horizontal* are insignificant in level equation. While those turn out to be significantly positive in growth equation, but the impact looks weak. These results might indicate weak spillover effects from host countries in Japanese MNEs. Second, in contrast, the coefficients for *Vertical* is significantly positive in both level and growth equations. While the positive impact of VFDI on productivity level implies benefits from production process-wise vertical division of labor, that of VFDI on productivity growth may indicate benefits from strong learning-by-doing effects. Such a

[9] This table is constructed by employing the Basic Survey of Overseas Business and Activities.
[10] According to Kiyota et al. (2008), average intra-firm trade ratio for Japanese multinationals exceeds 90%.

difference in productivity impact between HFDI and VFDI is consistent with our theoretical discussion in the section 2.

In addition, we have decomposed the VFDI index into *Upstream* and *Downstream*, corresponding to the relocation abroad of upstream activities and of downstream activities, respectively. It is found that coefficients for both *Upstream* and *Downstream* are estimated to be significantly positive. Our presumption is that VFDI's productivity impact is prominent in domestically-remained upstream activities, because downstream activities, typically labor-intensive assembly, are moved abroad and are engaged in vertical division of labor with the upstream activities at home. However, due to the complex nature of production system in electronics industry as found in Table 3, the positive effects of VFDI would be found in both upstream and downstream activities.

=== Table 5 ===

In order to further investigate such impacts, we focus on the Japanese overseas activities in East Asian countries. That is, the numerator of two FDI variables consists of only East Asian countries, not all foreign countries. Such focus on East Asia is invaluable in terms of at least two points. First, as found in Table 2, since East Asia is the most important region for Japanese MNEs, it enables us to uncover the impacts of FDIs with the most influence for their performance at home. Second, it might contribute to controlling labors' skill heterogeneity between developed and developing countries. For example, labors in OECD countries have the superior skill than those in East Asian countries. The restriction to East Asian countries in the two FDI variables enables us to avoid summing up labors with different skill, at least in the numerator. MNEs' activities in developed countries and other countries are controlled by introducing two variables; $FDI_{Developed}$ and FDI_{Others}. Their numerator is employment in those countries, and the denominator is the same formulation as that of *Vertical*.

The basic statistics and the regression results are reported in Tables 4 and 6, respectively. First, coefficients for *Horizontal* are never significant. Since the source of positive impact of HFDI is excellent knowledge that MNEs can obtain in host countries, the spillover of such knowledge would be usually available in developed countries. This argument is consistent with the insignificant results of HFDI in East Asia, which consists of many developing countries. Second, although the results in VFDI-related variables are qualitatively unchanged with those in Table 5, the magnitude of all the coefficients for them experiences a remarkable rise. This result is consistent with the general argument that the larger the differences in factor prices between home and host countries, the larger benefit the VFDI firms could enjoy. Third, FDI in East Asia has positive impact on both upstream and downstream activities. Again, the magnitude of these coefficients becomes large as compared to those in Table 5.

=== Table 6 ===

Last, in order to check the validity of using activity-level data, we also run the

same regression using firm-level data.[11] The equation to be estimated is given by:

$$TFP_i(t) = \rho\, TFP_i(t\text{-}1) + \beta_1\, Horizontal_i(t\text{-}1) + \beta_2\, Vertical_i(t\text{-}1) + \delta(t) + \eta_i + \varepsilon_i(t),$$

$$\Delta TFP_i(t) = \lambda\, \Delta TFP_i(t\text{-}1) + \gamma_1\, Horizontal_i(t\text{-}1) + \gamma_2\, Vertical_i(t\text{-}1) + \delta(t) + \eta_i + \varepsilon_i(t),$$

where TFP_i (t) and ΔTFP_i (t) denote the level of and the first-difference of productivity in firm i in year t, respectively. $Horizontal_i$ and $Vertical_i$ are calculated as:

$$Horizontal_i = \frac{\sum_{r \in R_O} L^r_{ih}}{\sum_{r \in R} L^r_{ih}}, \quad Vertical_i = \frac{\sum_{r \in R_O} \sum_{k \in S_h} L^r_{ik}}{\sum_{h \in S} \sum_{r \in R} L^r_{ih}}.$$

L^r_{ih} represents firm i's activity h's employment in country r. Activity h is the one with the largest sales share in firm i's all activities. As is shown in Table 7, the coefficients for *Horizontal* and *Vertical* become to be insignificant. In the regression results of *Upstream* and *Downstream* indicators, all coefficients except for *Downstream* in growth equation are estimated to be insignificant. As a result, the striking differences of this firm-level result from the results in Table 5 and 6 (for activity-level data analysis) confirm that our presumption that murky relationship between FDI and productivity comes from the data problem. That is, the results in firms-level analysis contain not only learning effects but also various elements attributed to VFDI firms' activity change, resulting in yielding some noises in coefficients for VFDI-related variables. Thus, an activity-level data can be used as a sharper knife to cut into their performance.

=== Table 7 ===

5. Concluding Remarks

In this paper, we have analyzed the impacts of Japanese electronic firms' FDI on their domestic activities in detail. In contrast to the previous studies, we have found consistent results with the theory; the VFDI enhances significantly the productivity of remaining activities in Japan, while the HFDI's productivity impact is not so clear. Thanks to a novel dataset at activity-level, we could conclude the positive impacts of FDI on productivity, while only inconclusive answers are provided by firm level analysis in the part literature.

We would conclude this paper with some important avenues to the literature. First, it is important to take into account the more complicated nature of FDIs. Recently, the FDI theories are reconstructed in the framework of three-country, not traditional two-country setting (Ekholm et al., 2007; Grossman et al., 2006; Yeaple, 2003). In particular, traditional VFDI is conceptually divided into pure VFDI and complex VFDI. The former type of VFDI is production process-wise division of labor between host and home countries, i.e. between two countries. The latter type is that among home and more than one host country, i.e. among more than two countries. Although this paper does not distinguish such two kinds of VFDI, it is natural that impacts on domestic activities' performance are different between them.

[11] We constructed firm-level data by aggregating activity-level data. Thus, our observations are restricted to manufacturing activities.

Second, the impacts of FDI on firm-level productivity should be further investigated as well. In either HFDI or VFDI, the shift of some particular production activities abroad will cause reallocation of labor resources inside the firm. Then, its speed may be an important issue for a firm as a whole to gain productivity rise. Since our dataset in this paper enables us to examine changes of employment across firm's activities, such examination on the reallocation of labor resources will be another venue of future research based on our dataset.

Appendix A. Data Construction

Our primary data source in this paper is the linked data base of The Census of Manufacturing (COM), The Basic Survey of Japanese Business Structure and Activities (BSJBSA) and The Survey of Oversea Business and Activity (SOBA) by the Ministry of Economy, Trade and Industry (METI). In this appendix, we introduce the basic information on these surveys and briefly explain the procedure of data construction.

A) The Census of Manufacturing

The Census of Manufacturing is one of the representative surveys of economic activity and its origin is data back to 1868, the first year of Meiji Restoration. The Census covers all the establishments in manufacturing sector listed in the Standard Industrial Classification for Japan. The Census is conducted on all establishments in years ending with 0, 3, 5 and 8 of the calendar year. For other years, the Census covers establishments with 4 or more employees. The Census consists of Form A for establishments with 30 or more employees, and the simpler Form B for establishments with 29 or fewer employees. The total number of establishments covered in 2003 is about 504,530, of which about 46,284 fall into the Form A category.

Major items in the Census are shipments, inventors, book values of equipment and structures, employment, cost of materials and energy usage. However, in Form B, the availability of information on book values of equipment and structures, and depreciation are restricted. Establishments with 9 or fewer employees are not required to report these items. And after year 2000, that information for establishments with 29 or fewer employees is available only in every 5 years[12].

B) The Basic Survey of Japanese Business Structure and Activities

The Basic Survey of Japanese Business Structure and Activities (BSJBSA) is the comprehensive firm-level survey conducted by Ministry of Economy, Trade and Industry. This survey started in 1991, then in 1994, and annually afterwards. The main purpose of the survey is to capture statistically the overall picture of Japanese corporate firms in light of their activity diversification, globalization, and strategies on research and development and information technology. The strength of the survey is its sample coverage and reliability of information. The survey includes all firms with more than 50 employees and with capital of more than 30 million yen. The survey covers mining, manufacturing, and service industries, although some services industries, such as finance, insurance, and software services, are not included. The other feature of this survey is that each firm has their own identification number (hereafter, the BSJBSA code) through out sample periods. Therefore, it is easy for researchers to construct a panel data set. The limitation of the survey is that information on financial and institutional features, such as keiretsu, are not available

[12] The compilation of the micro data of the Census of Manufacturing was conducted by a group of several researchers and the member of Quantitative Analysis Database division at Research Institute of Economy, Trade and Industry (RIETI): Kazushige Shimpo (Keio University), Kazuyuki Motohashi (The University of Tokyo), Toshiyuki Matsuura (Hitotsubashi University), Kyoji Fukao (Hitotsubashi University), Hyeog Ug Kwon (Nihon University), Mutsuharu Takahashi, and Tami Ohomori (RIETI). See also Motohashi (2002), Shimpo et al. (2004), Fukao et al. (2006) and Matsuura et al. (2007).

and small firms with less than 50 workers (or with capital of less than 30 million yen) are excluded. The number of firms exceeds 20,000 annually.

For analysis, it might be better to extend the coverage of "firm": particularly in this paper, our definition of a firm includes its wholly-owned firms (subsidiaries). In Japan, manufacturing firms often relegate production activities to their subsidiaries. However, since the firm-level data in the BSJBSA is basically non-consolidated accounting, production activities by wholly or majority owned domestic affiliates are excluded from MNEs' productivity measurement[13]. Such exclusion might induce significant measurement error and lead to an incorrect observation. To address such an error, we extend the coverage of "firm" like above. Practically, to this end, we need to identify each firm's parent and further parent's BSJBSA code. The BSJBSA reports the securities code of each firm's parent, and the METI presents the converter table for BSJBSA code and securities code during the period 1991-2000. Employing such a METI converter table, we can identify parent's BSJBSA code of firms even during the period 2001-2003 if their parent's securities code is available during the period 1991-2000.

C) The Survey of Oversea Business and Activity

The Survey on Overseas Business and Activities (SOBA) is also the firm-level survey by Ministry of Economy, Trade and Industry. The aim of this survey is to obtain basic information on the activities of foreign affiliates of Japanese firms. The survey covers all Japanese firms that had affiliates abroad. The survey is consisted of 2 parts. One is the Basic Survey which is more detailed and carried out every 3 years. The other is the Trend Survey which is comparatively rough and carried out between the Basic Surveys. A foreign affiliate of a Japanese firm is defined as follows;

1. A foreign affiliate in which a Japanese corporation has invested capital of 10% or more
2. A foreign affiliate in which a "subsidiary," funded more than 50% by a Japanese corporation, invested capital of more than 50%
3. A foreign affiliate in which a Japanese corporation and a subsidiary funded more than 50% by a Japanese corporation have invested capital of more than 50%

Major items in the SOBA are establishment year, breakdown of sales and purchase, employment, cost, and research and development and so forth. For further information on the items in the SOBA, see "Survey Form for Oversea Affiliates and "Guide for Completing the Survey".[14]

For microdata of the SOBA, there is no affiliate's unique identification number. Therefore, we carried out the data linkage by using the information on affiliates location, name, establishment year, and so forth and construct panel data set[15].

D) Development of linked-database

[13] According to Financial Statement of Sonny, domestic production of battery, semiconductors and vide camera are operated by wholly owned affiliates.

[14] Downloadable form METI web site:
http://www.meti.go.jp/english/statistics/tyo/kaigaizi/index.html.

[15] For details of the BSOBA panel dataset, see also Kiyota, et al. (2008).

In this section, we report our procedures of the link of these three data. At first, we link plant data from the COM and firm data from the BSJBSA. Although both surveys are conducted by the METI, each survey has original firm identification (ID) code respectively and there is no matching table between the code in the COM and the code in the BSJBSA. Therefore, we match firms between the COM and the BSJBSA, referring to the firms' name, their telephone number, and their other information such as address. In addition, though the firm ID number for the COM is available from 1994 to 2003, the firm ID number is drastically revised between 1996 and 1997. Thus, we need to make matching table by ourselves by referring to the firm ID number of continuing plants. Consequently, the result of the link between the COM and the BSJBSA seems to be good enough. The ratio of the number of matched plants data to the number of total manufacturing establishments reported in the BSJBSA is more than 95%.[16]

Next, the BSOBA is linked with the BSJBSA. First of all, since the METI revised parent firm code every year for BSOBA 1995, we make matching table for parent firm code and complete panel dataset. Second, based on the firms' information, we match firms between the BSJBSA and the BSOBA. While the BSOBA covers almost all industries except for Finance and Insurance, the coverage of the BSJBSA is restricted to mining, manufacturing, wholesale and retail, and some service industry. Therefore, not all foreign affiliates in the BSOBA are linked with BSJBSA.

[16] Note that since the BSJBSA covers the firms with more than 50 employees and 30 million capital amounts, the establishments which belong to small enterprises, cannot be linked with firm-level data. The ratio of the number of matched plants to total number of plants in the COM is about 10%.

Appendix B. Construction of Variables in TFP Index

Output, intermediate input, labor input and deflator

The real value added is defined as real gross output minus real intermediate input. Real gross output is measured as the shipments deflated by output deflator, and intermediate input as the cost of materials deflated by input deflator. Labor input is measured by total number of employment multiplied by the spectral working hours form System of National Accounts (Cabinet Office in Japan). The labor input is also employed in probit/multinominal logit as independent variables. All output and input deflators are obtained from the JIP database 2006 (Fukao et al., 2006).

Capital stock

Following Fukao et al. (2006), we estimated capital stock with the nominal book values of tangible assets by multiplying the ratio of the net stock to the book value of industry-level capital.[17] Net capital stocks by industry are derived from JIP database 2006, and the book values of capital by industry are obtained by aggregating "Census of Manufacturing".

Cost share

We need shares of labor cost, intermediates costs, and capital costs in total costs. Labor costs are defined as total salaries, and intermediates costs as the sum of raw materials, fuel, electricity and subcontracting expenses for consigned production. Capital costs are calculated by multiplying the real net capital stock with the user cost of capital, P_K. The latter is estimated as follows:

$$P_K = P_I\left(r_t + \delta - \dot{P}_I \big/ P_I\right),$$

where P_I is the price of investment goods, r the interstate, and δ the depreciation rate. Data on the price of investment goods and the depreciation rate are calculated with the investment and capital stock matrix in JIP database 2006.[18] Interest rates (10-year-bond yield) are from Bank of Japan.

[17] Fukao, Kim and Kwon (2006) propose to use the ratio of net stock to the book value of capitals by type of assets. In the census, however, the book values of capital by type of assets are available only for those plants that have more than 30 employments. Therefore, in order to include small establishments in our sample, we did not calculate the ratio of net stock to the book value of capital by type of assets.

[18] JIP database reports the investment and the capital stock matrices by 108 industry and 39 types of assets. We calculated the weighted average of price index for the investment goods and the depreciation rate by industry.

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Figure 1. Impact of HFDI on Home Plant's Average Cost

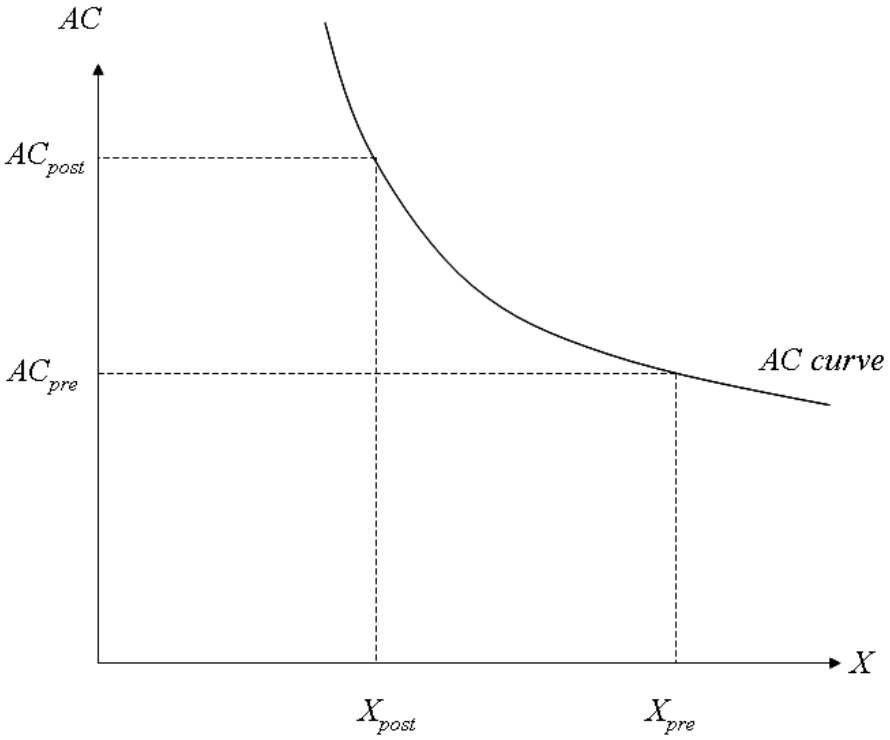

Figure 2. Impact of HFDI on Home Plant's Average Cost, with Spillover

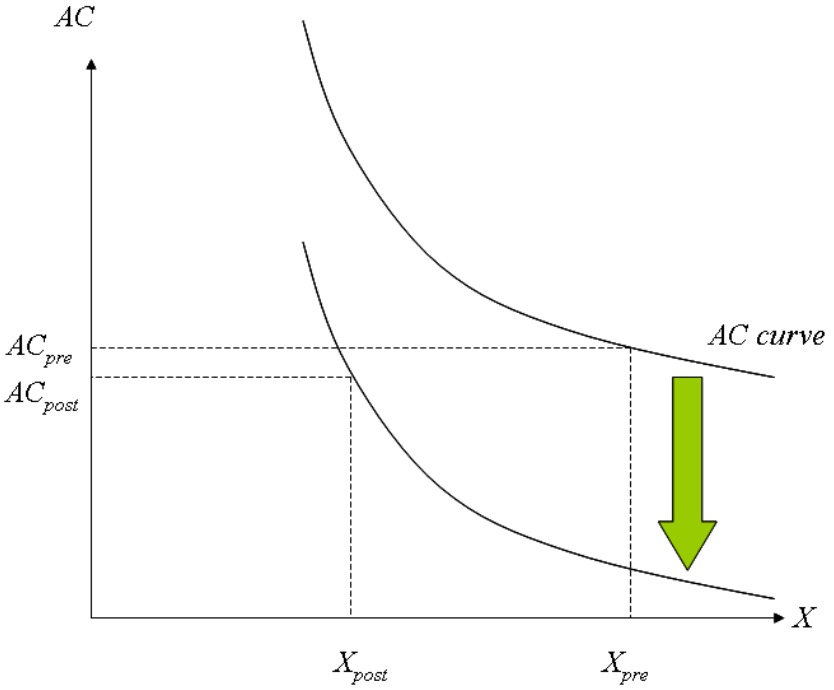

Figure 3. Impact of VFDI on Home Plant's Average Cost

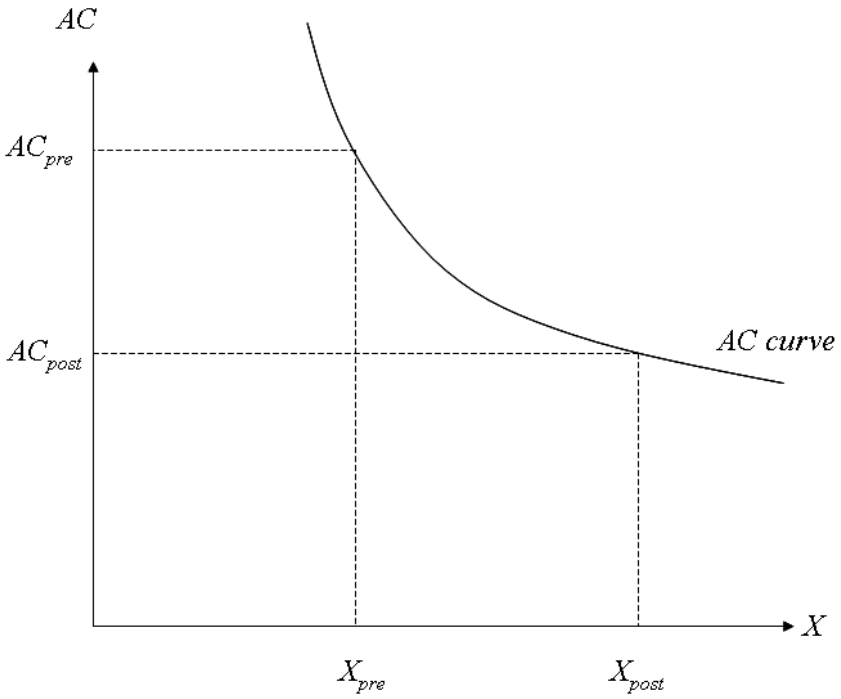

Table 1. Example

	Upstream	Downstream
Home	*A*	*B*
East Asia		*D*
North America	*C*	*E*

Table 2. Combination between Home and Abroad in 2000

		No Entry	Abroad	
			Downstream	Upstream
Home	Downstream	1249 (1275)	174 (148)	113 (107)
	Upstream	723 (737)	81 (69)	124 (112)

Source: Authors' calculation by using the Basic Survey of Overseas Business and Activities
Notes: The numbers of firms with activities concerned only in East Asia are in parentheses. "No Entry" means non-MNEs (firms not investing to East Asia).

Table 3. Trade between Home and Overseas Affiliates

	NAmerica	Europe	ASEAN	NIES	China
A Share of Imports from Japan in Total Procurements					
Downstream					
Office machines	44.7%	38.9%	37.9%	50.7%	24.0%
Household electric appliances	36.6%	44.0%	23.6%	32.1%	27.3%
Industrial electrical apparatus	32.9%	49.7%	47.1%	40.1%	49.0%
Electronic data processing machines	52.2%	42.4%	30.6%	47.5%	38.1%
Communication equipment	42.8%	36.9%	33.0%	27.0%	39.4%
Upstream					
Electronic parts and devices	50.7%	47.0%	39.8%	41.4%	46.9%
Semiconductor	63.9%	70.4%	84.5%	75.1%	90.9%
A Share of Exports to Japan in Total Sales					
Downstream					
Office machines	2.5%	0.2%	24.6%	52.2%	32.2%
Household electric appliances	1.6%	12.2%	16.2%	22.8%	17.2%
Industrial electrical apparatus	3.5%	0.8%	34.3%	11.5%	23.6%
Electronic data processing machines	4.1%	1.4%	37.3%	25.5%	21.0%
Communication equipment	4.8%	6.2%	33.4%	23.9%	24.5%
Upstream					
Electronic parts and devices	7.3%	3.8%	28.6%	16.2%	37.5%
Semiconductor	16.4%	9.2%	50.7%	23.6%	54.8%

Source: Authors' calculation by using the Basic Survey of Overseas Business and Activities

Table 4. Basic Statistics

	N	Mean	Sd	p10	p90
Activity-level					
△TFP	32,897	0.024	0.243	-0.137	0.202
TFP	32,897	0.949	0.695	0.000	1.785
Horizontal	32,897	0.100	1.654	0.000	0.000
Vetical	32,897	0.030	0.663	0.000	0.000
Upstream	32,897	0.021	0.648	0.000	0.000
Downstream	32,897	0.009	0.143	0.000	0.000
Activity-level (East Asia estimation)					
$FDI_{Developed}$	32,897	0.085	1.285	0.000	0.000
FDI_{Others}	32,897	0.024	0.308	0.000	0.000
Horizontal	32,897	0.019	0.103	0.000	0.000
Vetical	32,897	0.007	0.107	0.000	0.000
Upstream	32,897	0.004	0.080	0.000	0.000
Downstream	32,897	0.003	0.072	0.000	0.000
Firm-level					
△TFP	29,322	0.029	0.249	-0.146	0.221
TFP	29,322	0.942	0.668	0.000	1.725
Horizontal	29,322	0.097	1.678	0.000	0.000
Vetical	29,322	0.013	0.316	0.000	0.000
Upstream	29,322	0.008	0.286	0.000	0.000
Downstream	29,322	0.005	0.134	0.000	0.000

Source: Authors' calculation by using the Basic Survey of Overseas Business and Activities

Table 5. Activity-level Results

	Level		Growth	
	(I)	(II)	(I)	(II)
Dependent Var. (*t*-1)	0.768	0.772	-0.158	-0.152
	[44.62]***	[46.16]***	[-9.38]***	[-9.08]***
Dependent Var. (*t*-2)	0.169	0.156		
	[8.60]***	[7.12]***		
Dependent Var. (*t*-3)	0.131	0.135		
	[7.63]***	[7.44]***		
Horizontal (*t*-1)	0.005	0.005	0.006	0.005
	[1.64]	[1.47]	[1.96]*	[1.67]*
Vetical (*t*-1)	0.005		0.004	
	[1.95]*		[1.77]*	
Upstream (*t*-1)		0.004		0.004
		[1.98]**		[2.01]**
Downstream (*t*-1)		0.023		0.029
		[3.49]***		[4.79]***
Time Fixed Effect	Yes	Yes	Yes	Yes
Activity Fixed Effect	Yes	Yes	Yes	Yes
Hansen *J* (p-value)	0.014	0.061	0.288	0.647
AR(2) (p-value)	0.533	0.369	0.322	0.418
No. Observations	23,977	23,977	27,985	27,985
No. Firms' Activities	3,242	3,242	3,682	3,682

Notes: z-values are in parentheses. ***, **, and * show 1%, 5%, and 10% significant, respectively.

Table 6. Activity-level Results for East Asia

	Level		Growth	
	(I)	(II)	(I)	(II)
Dependent Var. (t-1)	0.770	0.773	-0.154	-0.148
	[46.53]***	[46.98]***	[-9.28]***	[-8.79]***
Dependent Var. (t-2)	0.162	0.162		
	[7.60]***	[7.47]***		
Dependent Var. (t-3)	0.120	0.117		
	[6.47]***	[6.43]***		
$FDI_{Developed}$ (t-1)	-0.004	-0.004	-0.003	-0.003
	[-1.32]	[-1.13]	[-1.31]	[-1.30]
FDI_{Others} (t-1)	0.039	0.036	0.042	0.040
	[1.81]*	[1.65]*	[3.37]***	[3.07]***
Horizontal (t-1)	-0.015	-0.019	0.004	0.003
	[-0.57]	[-0.70]	[0.16]	[0.12]
Vetical (t-1)	0.062		0.056	
	[4.06]***		[5.15]***	
Upstream (t-1)		0.076		0.067
		[4.07]***		[5.43]***
Downstream (t-1)		0.046		0.055
		[6.03]***		[6.00]***
Time Fixed Effect	Yes	Yes	Yes	Yes
Activity Fixed Effect	Yes	Yes	Yes	Yes
Hansen J (p-value)	0.102	0.218	0.495	0.667
AR(2) (p-value)	0.631	0.657	0.391	0.510
No. Observations	23,977	23,977	27,985	27,985
No. Firms' Activities	3,242	3,242	3,682	3,682

Notes: z-values are in parentheses. ***, **, and * show 1%, 5%, and 10% significant, respectively.

Table 7. Firm-level Results

	Level		Growth	
	(I)	(II)	(I)	(II)
Dependent Var. (*t*-1)	0.768	0.771	-0.147	-0.145
	[45.30]***	[45.16]***	[-8.26]***	[-8.05]***
Dependent Var. (*t*-2)	0.158	0.159		
	[6.91]***	[6.85]***		
Dependent Var. (*t*-3)	0.156	0.154		
	[9.22]***	[9.21]***		
Horizontal (*t*-1)	0.003	0.002	0.004	0.003
	[0.87]	[0.85]	[1.07]	[0.92]
Vetical (*t*-1)	0.006		0.010	
	[0.61]		[0.99]	
Upstream (*t*-1)		0.006		0.009
		[0.50]		[0.80]
Downstream (*t*-1)		0.011		0.022
		[1.13]		[2.67]***
Time Fixed Effect	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes
Hansen *J* (p-value)	0.177	0.910	0.347	0.960
AR(2) (p-value)	0.261	0.279	0.390	0.436
No. Observations	23,744	23,744	26,417	26,417
No. Firms' Activities	2,666	2,666	2,792	2,792

Notes: z-values are in parentheses. ***, **, and * show 1%, 5%, and 10% significant, respectively.