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In this paper we statistically test the validity of the mechanics of complex VFDI in Japanese machinery FDI to East Asia; we do this by estimating a multiple-spatial lag model. From the theoretical point of view, in complex VFDI, the production activity of affiliates in a given country is positively related to that in neighboring countries which have large differences in factor prices with the given country. Our empirical results show that such mechanics of complex VFDI work in Japanese FDI to East Asia, and that they work more strongly in the MNEs with higher productivity. These results have an important implication for the policies of developing countries in attracting FDI.

Keywords: Third-country effects; Complex VFDI, Spatial lag model
JEL classification: F21; F23

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Complex Vertical FDI and Firm Heterogeneity: Evidence from East Asia

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Abstract: In this paper we statistically test the validity of the mechanics of complex VFDI in Japanese machinery FDI to East Asia; we do this by estimating a multiple-spatial lag model. From the theoretical point of view, in complex VFDI, the production activity of affiliates in a given country is positively related to that in neighboring countries which have large differences in factor prices with the given country. Our empirical results show that such mechanics of complex VFDI work in Japanese FDI to East Asia, and that they work more strongly in the MNEs with higher productivity. These results have an important implication for the policies of developing countries in attracting FDI.

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1. Introduction

In the recent wave of globalization, the vertical division of labor among production stages has developed worldwide. The well-known example is automobile production in the US-Mexico nexus. Cross-border production sharing between the US and Mexico has been accompanied by back-and-forth intra-firm transactions between headquarters in the US and their assembly plants in Maquila, Mexico. The WE (Western Europe)-CEE (Central and Eastern Europe) nexus is another example. Indeed, exports of finished machinery products from CEE to WE have experienced a rapid increase.[1] Such a division of labor is clearly important for the economic growth of developing countries. It encourages the transfer of the superior know-how and technology in developed countries to developing countries, thereby contributing to the enhancement of firm productivity in the developing countries.

There have been a number of theoretical papers that have sought to clarify the mechanics of the vertical division of labor among production processes (e.g., Jones and Kierzkowski, 1990). Academically this division of labor has become virtually interchangeable with the terms fragmentation, outsourcing, or vertical specialization. Fragmentation is the splitting of a product process into two or more steps that lead to the same final product. When a fragmented production block is placed beyond national borders, the fragmentation is called "international fragmentation" or "cross-border fragmentation". International fragmentation is also discussed within the context of vertical foreign direct investment (VFDI). Studies show that theoretically once fragmentation becomes possible due to trade cost reductions, multinational enterprises (MNEs) in a country (often termed a developed country) locate their affiliates in a country (often termed a developing country) which has a comparative advantage in assembly processes. The MNEs then engage in a production-process vertical division of labor by exporting intermediate products to their affiliates. This two-country version of VFDI has recently come to be known as "pure VFDI".

However, "traditional" theories of the vertical division of labor, e.g. pure VFDI theory, cannot adequately explain the recent expansion in the more complicated international production systems. UNCTAD (2002) states that: *During the past 15 years, falling barriers to international transactions have not only invigorated global markets through arm's-length transactions but given rise to elaborate corporate systems of organizing the production process. As a result, international production systems have emerged within which TNCs[MNEs] locate different parts of the production processes, including various services functions, across the globe, to take advantage of fine*

[1] See Ando and Kimura (2007) and Hanson et al. (2005).

differences in costs, resources, logistics and markets. As Yeaple (2003) and Grossman et al. (2006) have pointed out, such MNE strategy is known as complex integration strategy (UNCTAD, 1993; 1998). The production systems in this strategy are accompanied by a production-process vertical division of labor involving more than two countries and are surely one form of VFDIs. However, traditional VFDI theory cannot depict these complicated production systems because pure VFDI theory assumes a model in which each MNE selects *one* country with the lowest production costs in activities that it wishes to relocate among all potential destination countries. That is, in pure VFDI theory, MNEs are supposed to engage in a vertical division of labor between two countries (host and home countries). Thus, we need a VFDI model that allows MNEs to have multiple affiliates in order to get more detailed insight into recent international production systems.

"Complex VFDI" theory could be the model for exploring the mechanics of the more complicated international production systems. Recently third-country effects have attracted much more attention in FDI theories which are being reconstructed in a three-country framework, not the traditional two-country setting (Baltagi et al., 2007; Ekholm et al., 2007; Grossman et al., 2006; Yeaple, 2003). As briefly illustrated in section 3, complex VFDI is a model in which an MNE sets up its vertical chain of production across multiple countries to exploit the differences in factor prices. Imagine that an MNE in a country (home country) locates its affiliate in another country (host country) and becomes engaged in the vertical division of labor between the two countries. If production processes in the host country can be further fragmented, and near the host country there is yet another country (third country) with comparative advantages in undertaking a part of the processes done in the host country, the MNE will relocate such a part of the processes from the host country to the third country. The result is that the MNE now has two affiliates and engages in a three-country vertical division of labor. This MNE strategy is like the one in the aforementioned recent international production systems. Thus, complex VFDI theory would be helpful for examining their mechanics.

In this paper we statistically test the validity of the mechanics of complex VFDI in Japanese machinery FDI to East Asia. International production and distribution networks in East Asia have developed dramatically in the machinery industries, particularly in the electronic machinery industry, since the 1990s. Indeed, East Asia consists of countries with different levels of economic development (i.e. different factor prices), and thus is a suitable region for the development of a production-process vertical division of labor among multiple countries. Japanese MNEs in particular have played the most important role in developing such networks. By diversifying the location of their affiliates, they have extended their international production networks all over East Asia. As a result, each Japanese MNE often has more than one affiliate within East Asia, as we will see in the next section. Such Japanese MNE strategy in East Asia implies that Japanese machinery FDI to that region can be a good example of the above-mentioned complicated production systems of MNEs. In this paper we apply the complex VFDI theory to explore Japanese machinery FDI to East Asia in the electronic machinery industry. Such an analysis will contribute to our understanding of the mechanics of recent more complex international production systems.

We first classify Japanese machinery FDI to East Asia by FDI type and find that most of the Japanese affiliates in East Asia producing information and communication electronics equipment and electronic parts and devices are complex VFDI. With this finding in mind, we next investigate the relationships of geographical proximity and factor price differentials among affiliates of an MNE. According to our model, in complex VFDI, overseas plants are linked with one another through proximity and factor price differentials among countries. If this argument is correct, we should find a positive relationship in Japanese FDI to East Asia in the production of information and communication electronics equipment and electronic parts and devices. To examine such relationships, we employ spatial econometric techniques, particularly a spatial-lag model.[2] Furthermore, this paper extends conceptually the complex VFDI model so as to allow for heterogeneity among firms. The well-known Melitz model tells us that only firms with higher productivity can afford to pay the costs for exporting activity and moving overseas (Melitz, 2003; Helpman et al., 2004). Clearly complex VFDI is a fixed-cost-consuming strategy because it costs firms a great amount to set up affiliates in multiple countries. This argument implies that compared with firms with low productivity, firms with high productivity are likely to undertake complex VFDI. We statistically test this argument by augmenting our spatial-lag model.

Our paper is in line with other empirical studies. First, it is related to Feinberg and Keane (2006) in the sense that we classify FDI according to certain criteria (which is presented in the next section). Feinberg and Keane used Bureau of Economic Analysis data on U.S. MNEs and found that 12% and 19% of them are pure horizontal FDI (pure HFDI) and pure VFDI, respectively, while the rest have adopted more complex integration strategies. Our paper further identifies quantitatively the complex FDI of the vertical type among the MNEs adopting complex integration strategies. Second, our paper is related to the studies that analyze FDI by spatial econometrics (Coughlin and

[2] See Anselin (1988) for more details of spatial econometrics,.

Segev, 2000; Baltagi et al., 2007; Blonigen et al., 2007). In particular, our paper is closest to Blonigen et al. (2007), which estimates the spatial-lag model and seeks to empirically differentiate FDI types (pure HFDI, export-platform, pure VFDI, and complex VFDI) in US outbound FDI. Although our paper basically follows the methodology employed in Blonigen et al. (2007), we introduce weighting matrices not only for bilateral distance but also for wage gaps based on the predictions of our model. This enables us to more successfully test the validity of the mechanics of complex VFDI. Third, our analysis on the relationship between overseas activity and firm productivity is clearly in line with a large number of firm-level studies, e.g., Bernard and Jensen (1999) and Head and Ries (2003). Our analysis of the relationship between firm productivity and their choice of VFDI strategy adds new facts to this literature.

The remainder of this paper is organized as follows. The next section presents some preliminary evidence on Japanese machinery FDI. In section 3, we describe the problem of selecting a VFDI pattern, i.e., pure VFDI or complex VFDI. Section 4 explains our empirical methodology for examining the mechanics of Japanese FDI to East Asian countries, and section 5 reports our regression results. Section 6 presents our conclusions.

2. Overview of Japanese Machinery FDI

Before discussing the specifications of analysis, we will present some preliminary evidence on Japanese machinery FDI. To do this, we use the micro database of *Kaigai Jigyou Katsudou Kihon (Doukou) Chousa* (*Survey on Overseas Business Activities*, hereafter SOBA) prepared by the Research and Statistics Department, Ministry of Economy, Trade and Industry (hereafter, METI). More details on this database are provided in section 4. As will be argued later, we employ data on the intra-firm trade of affiliates to identify complex VFDI. Thus, this section restricts the sample period only to years in which such data are available: 1995, 1998, and 2001. The country list is presented in Appendix A.

Table 1 presents the average number of overseas manufacturing affiliates by region, parent-company size and industry for Japanese machinery MNEs. Parent-company size is measured by the number of employees. Four points are noteworthy. First, there is a difference in the average number of affiliates depending on region. Japanese MNEs in almost all machinery industries, irrespective of parent size, own more than two manufacturing affiliates in both Asia and Europe while the average number of such affiliates in North America is around one. Second, in Asia and Europe there are marked differences among parent industries in the number of affiliate. In Asia MNEs in the information and communication devices industry have more than three manufacturing affiliates on average while those in the transportation equipment and precision instruments industries have less than two manufacturing affiliates. The same is also true for Europe, but we do not find such a difference for North America. Third, there seems to be a positive correlation between parent size and the number of overseas manufacturing affiliates. In the case of the general machinery industry in Asia in 1995, for example, while the average number of manufacturing affiliates for large firms was 2.52, that for small firms was 1.21. The same sort of ratio can be seen in other years, other industries, and other regions, particularly Europe. Fourth, there has been an upward trend in the average number of overseas manufacturing affiliates in Asia for large firms, but not for small ones. In the general machinery industry in Asia, for example, small firms had on average 2.91 and 2.37 affiliates in Asia in 1995 and 2001, respectively; during the period the average number of affiliates for large firms increased from 3.87 to 4.17. Another outstanding point is that such an upward trend can only be seen in Asia.

== Table 1 ==

Turning to the type of manufacturing affiliates, Table 2 shows the ratio of vertical-type overseas affiliates to all overseas manufacturing affiliates by region and industry. While HFDI is investment for the purpose of avoiding broadly-defined trade costs by setting up plants within a targeted market/country rather than by exporting from the home country, VFDI is for exploiting the low price-production factors of the host country. In other words, most of the goods produced by HFDI affiliates are intended for sale in the host country, but the sale of products from VFDI affiliates is basically not aimed at the host country. Thus, we define VFDI statistically as affiliates in which the share of local sales to total sales is less than 50%. Table 2 shows that compared with affiliates in North America and Europe, those in Asia tend to be the vertical type; more than half of the affiliates in Asia are vertical type. In the case of information and communication devices in 2001, for example, 58% of Asian affiliates were the VFDI type while for North America and Europe it was 22% and 16%, respectively. This result indicates the substantial growth that the vertical production networks of Japanese MNEs have experienced in Asia.

== Table 2 ==

In conducting our analysis, we decompose Japanese machinery VFDI into two types, pure and complex VFDI. We define the following affiliates as complex VFDI: affiliates with intra-firm sales to and intra-firm procurements from third countries, affiliates with both intra-firm sales to third countries and intra-firm procurements from Japan, and affiliates with both intra-firm sales to Japan and intra-firm procurements from third countries.[3] Table 3 compares the ratio of complex VFDI to the pure type. Compared with North America and Europe, the ratios are again higher in Asia. In the electronic machinery and information devices industries in particular, near half of all the VFDI affiliates are of the complex type. Furthermore, the ratios in the two industries rise slightly during the sample period, accounting for 40% and 42% respectively in 2001.

== Table 3 ==

Table 4 shows that the ratio of complex VFDI in Asia is a little higher for affiliates that belong to parents with more than 1,000 employees. In 2001, for example, 35% of Asian affiliates in large MNEs were complex VFDI types while 31% were classified as such in small MNEs. This fact suggests that large MNEs enjoy more benefits from a vertical chain of production across multiple countries. Table 5 provides the ratio for complex VFDI according to firm productivity. We measured this productivity using total factor productivity (TFP), about which details will be presented later. The results are qualitatively similar to those in Table 4, i.e., more productive firms are likely to have more complex VFDI affiliates.

== Tables 4 and 5 ==

3. The Model

This section examines the problem of selecting a VFDI pattern, i.e. pure or complex, in order to clarify the mechanics of complex VFDI. To do that, it is essential to extend the pure VFDI model to at least a three-country and three-production stage setting. Within this setting, this section will describe the kinds of countries that can

[3] In the classification of complex VFDI, the magnitude/ratio of intra-firm transactions is not taken into account. Furthermore, we actually do not examine if transactions with Japan are intra-firm or not since data on such transactions are likely to be not available and affiliate transactions with Japan are by and large intra-firm ones.

attract investment from the home country, while allowing for heterogeneity among firms in terms of productivity. It should be noted that the aim of this section is not to provide a general equilibrium model of multi-production-stage and multi-country VFDI but simply to get insights into the driving forces working behind VFDI to multiple countries with various factor prices in a partial equilibrium model.

3.1. Settings

Suppose that there are four countries: country 1 (home country), country 2, country 3, and a country in the outside economy. In this supposition we consider finished machinery products that are horizontally differentiated. Each of a continuum of firms manufactures a different brand with zero measure. The finished machinery products are consumed only in the outside economy and are transported from any of the three countries without any charge. Consumers in the outside economy country have the CES utility function in the consumption of brand *k*, $x(k)$, such that:

$$U = \left(\int_{k \in \Omega} x(k)^{\alpha} \, dk \right)^{\frac{1}{\alpha}}, \quad 0 < \alpha < 1.$$

Ω denotes a set of varieties available in the outside economy country. With this utility function we can derive the demand function of a brand as $x(k) = A\, p(k)^{-\varepsilon}$, where x is its quantity, p is its price,

$$A \equiv E \left(\int_{k \in \Omega} p(k)^{1-\varepsilon} \, dk \right)^{-1},$$

$\varepsilon \equiv 1/(1-\alpha)$, and E is the total expenditure in the outside country. A is a measure of the demand level and is taken as exogenous by producers.

The market structure of the finished machinery-goods sector is monopolistic competition. Firms and their headquarters are assumed to locate only in country 1 (home country) for simplicity. Each firm knows its cost efficiency θ only after its entry to the market. The machinery products are produced in three stages of production. The production function in each stage is kept as simple as possible to bring out the nature of dependence among production stages. Our Leontief-type production structure is as follows. A first stage product is produced inputting θ units of knowledge; a second stage product is produced inputting one unit of the first stage product and θ units of skilled-labor; a third stage product (i.e. finished machinery product) is produced with input of one unit of the second stage product and θ units of unskilled-labor. Factor prices for knowledge, skilled-labor, and unskilled-labor are represented by h, r, and w, respectively.

For simplicity we assume that only country 1 has knowledge, so that the first stage can be produced only in country 1, i.e. home country. It is also assumed that $w_1 > w_2 > w_3$ and that $r_1 > r_3 > r_2$, which indicate that the home country is generally the highest in both skilled and unskilled labor while countries 2 and 3 are the lowest in skilled and unskilled labor, respectively.[4] The assumption of factor prices order indicates simply that countries 2 and 3 have location advantages in producing the second-stage and third-stage products, respectively. There are ice-berg trade costs t_{ij} ($\geq$1) for the shipment of each stage-product between countries i and j (t_{ij} = 1 if i = j). Although firms do not need to pay any fixed costs if they produce all stage-products in only country 1, they must incur plant set-up costs f if they locate plants abroad. But if firms produce products of both the second and the third stages in country i, they only need to pay f, not $2f$.

Although the first stage of production always is located in country 1, there are still 9 (3x3) possible location combinations. Given the assumption on the order in factor prices, however, we can rule out four combinations. Let π_{lm} be gross profit in the production combination: (2nd stage country, 3rd stage country) = (l, m). Then it always holds that $\pi_{22} > \pi_{12}$, $\pi_{22} > \pi_{21}$, $\pi_{33} > \pi_{13}$, and $\pi_{33} > \pi_{31}$. This is because countries 2 and 3 have more location advantages in producing the second- and third-stage products than country 1. We also rule out the combination (3, 2).[5] As a result, we will need to consider only the following four combinations: (2nd stage country, 3rd stage country) = (1, 1), (2, 2), (3, 3), and (2, 3).

Let c_{lm} be total cost in the production pattern (l, m), then c_{11}, c_{22}, c_{33}, and c_{23} are given by:

$$c_{11} = (h_1\theta + r_1\theta + w_1\theta)x,$$
$$c_{22} = (t_{12}h_1\theta + r_2\theta + w_2\theta)x + f$$
$$c_{33} = (t_{13}h_1\theta + r_3\theta + w_3\theta)x + f$$
$$c_{23} = (t_{12}t_{23}h_1\theta + t_{23}r_2\theta + w_3\theta)x + 2f.$$

The profit-maximizing strategy yields $p = c^{ij}_x/\alpha$, where $c^{ij}_x = d\, c_{ij}/d\, x$, so that profits are

[4] Imagine country 2 as a NIE (namely, Singapore, Hong Kong, Taiwan, or Korea) and country 3 as an ASEAN developing country. Although both skilled and unskilled labor are generally not cheap in the NIEs, skilled labor is scarce in the ASEAN countries. As a result, skilled labor might become more expensive in the ASEAN countries than in the NIEs.

[5] Specifically, we assume that $(t_{12} - t_{13})\, t_{23}h_1 + t_{23}(r_2 - r_3) + (w_3 - w_2) < 0$. The combination (3, 2) is the production pattern that does not fully enjoy differences in factor prices between countries 2 and 3, particularly compared with the combination (2, 3). However, the combination (3, 2) is always more profitable than the combination (2, 3) if trade costs between home and country 2 are much higher than those between home and country 3 (i.e., $(t_{12} - t_{13})\, t_{23}h_1 + t_{23}(r_2 - r_3) + (w_3 - w_2) > 0$). But the aim of this type of multiple-country production is not to enjoy differences in factor prices but to reduce the total burden of trade costs. That is, trade with country 2 is not a vertical division of labor but purely entrepot trade. Such a production pattern is not our interest in this study.

given by:

$$\pi_{11} = (h_1 + r_1 + w_1)^{1-\varepsilon}\,\Theta$$
$$\pi_{22} = (t_{12}h_1 + r_2 + w_2)^{1-\varepsilon}\,\Theta - f$$
$$\pi_{33} = (t_{13}h_1 + r_3 + w_3)^{1-\varepsilon}\,\Theta - f$$
$$\pi_{23} = (t_{12}t_{23}h_1 + t_{23}r_2 + w_3)^{1-\varepsilon}\,\Theta - 2f,$$

where $\Theta \equiv A(1-\alpha)\alpha^{\varepsilon-1}\,\theta^{1-\varepsilon}$. We call Θ the productivity measure. Since $\varepsilon > 1$, the smaller the cost efficiency θ is, the larger the measure Θ is.

3.2. Pure VFDI vs. Complex VFDI

We will first consider the problem of selecting among (1, 1), (2, 2), and (3, 3), i.e. among domestic and two types of pure VFDI. If the location advantages in producing the second- and third-stage products in countries 2 and 3 are trivial compared with country 1, π_{11} is always higher than π_{22} and π_{33} due to the existence of trade costs between host and home countries. To shed light on the production pattern of interest in this study, i.e. the international production-stage division of labor, we restrict ourselves only to the cases where the location advantages in countries 2 and 3 are relevant. Specifically, we assume $(1 - t_{12})\, h_1 + (r_1 – r_2) + (w_1 – w_2) > 0$ and $(1 - t_{13})\, h_1 + (r_1 – r_3) + (w_1 – w_3) > 0$. Then, drawn as a function of the productivity measure Θ, π_{22} and π_{33} are steeper than π_{11}.

From the slope of π_{22} and π_{33}, however, we can draw two different figures concerning profits. Figure 1 depicts the case where country 2 has much lower factor prices for skilled labor or better access to the home country than country 3. Specifically, $h_1(t_{12} - t_{13}) + (r_2 - r_3) + (w_2 - w_3) < 0$. Then, since π_{22} is always higher than π_{33}, firms choose either the pure VFDI of the second and third production stages to country 2 or the domestic production of all stages (Domestic). As is evident from the figure, firms with high productivity choose the pure VFDI to country 2, while firms with low productivity choose the domestic production of all stages (Domestic) because variable profit cannot cover fixed costs f. Figure 2 shows the case where $h_1(t_{12} - t_{13}) + (r_2 - r_3) + (w_2 - w_3) > 0$. As in Figure 1, firms with high productivity choose pure VFDI to country 3, while firms with low productivity choose the domestic production of all stages. As a result, the partner of pure VFDI depends on whether $h_1(t_{12} - t_{13}) + (r_2 - r_3) + (w_2 - w_3)$ becomes positive or negative. Given the location advantages, to attract pure VFDI, foreign countries need to reduce trade costs with potential investing countries more greatly than competitors. As we will see below, however, such a “race to bottom” in trade costs with the investing countries does not necessarily occur if we allow the further geographical separation of production stages.

== Figures 1-2 ==

To see this, we add an alternative of "Complex VFDI", i.e. the pattern (2, 3). As with Figures 1 and 2, two different figures can be drawn according to the slope of π_{22} and π_{33}. At this stage, we restrict our attention only to the case where π_{22} is always higher than π_{33}, i.e. $h_1(t_{12} - t_{13}) + (r_2 - r_3) + (w_2 - w_3) < 0$. Furthermore, if the location advantages in producing the third-stage products in country 3 are trivial compared with country 2, the slope of π_{22} is always higher than that of π_{23} due to the additional burden of trade costs between host countries. Specifically, if $(t_{12}h_1 + r_2)(1 - t_{23}) + (w_2 - w_3) < 0$, complex VFDI never occurs. Below we will focus on the case where the slope of π_{22} is larger than that of π_{23}, i.e. $(t_{12}h_1 + r_2)(1 - t_{23}) + (w_2 - w_3) > 0$.

We can again draw two different figures. In Figure 3 the intersection between line π_{22} and line π_{23} lies on the right-hand side of the intersection between line π_{11} and line π_{22}. This emerges when, for example, the gap in factor prices for unskilled labor between countries 2 and 3 is not large enough or the trade costs between countries 2 and 3 are not low enough. In this figure, firms with high productivity choose complex VFDI, firms with medium productivity choose pure VFDI, and firms with low productivity choose domestic production of all stages. On the other hand, if gap in factor prices for unskilled labor between countries 2 and 3 is large enough or trade costs between countries 2 and 3 are low enough, as shown in Figure 4, complex VFDI becomes a more profitable strategy for firms than pure VFDI regardless of the level of productivity. Therefore, firms with low or high productivity choose domestic production and complex VFDI, respectively. In summary, the larger the gap in factor prices between host countries, i.e. countries 2 and 3, or the lower the trade costs between them, the more likely are firms to choose complex VFDI as their dominant strategy. Furthermore, firms with higher productivity tend to choose a complex VFDI strategy.

== Figures 3-4 ==

As can be seen from the above figures, the key drivers in our model are the gap in the factor prices and the trade costs among the countries. One important point is that not only trade costs between home and potential host countries but also those between host countries must be low enough for the development of multiple-country VFDI, i.e. complex VFDI. This implies that a country might attract a part of MNE production if the country reduces its trade costs with another country where a large number of MNEs have already invested. Another important point is that each country needs to have production stages that best match its location advantages compared to other countries. Thus, countries might be more successful in attracting MNEs by selectively encouraging the best parts of their production environment. Finally, taking geographical distance as the major source of trade costs, we can summarize the mechanics of complex VFDI as the following testable hypotheses:

Testable Hypothesis 1: *In complex VFDI, overseas plants are linked with one another through geographical proximity and factor price differentials among countries.*

Testable Hypothesis 2: *MNEs with high productivity are more likely to choose a complex VFDI strategy than those with low productivity.*

3.3. Other Types of FDI

So far, we have listed the characteristics of complex VFDI. In the remainder of this section, we will briefly summarize those of the other types of FDI, i.e., pure HFDI and export-platform FDI. We will examine in particular the relationship to the proximity and the factor price differentials of third countries in the other types of FDI.

Blonigen et al. (2007) studied the relationship of pure HFDI and export-platform FDI to the proximity of third countries. Regarding the former, they argue that the pure HFDI model *would not be associated with any spatial relationship between FDI into neighboring markets as the MNE makes independent decisions about the extent to which it will serve that market through exports or affiliate sales*. On the other hand, in export-platform FDI, *a parent country invests in a particular host country with the intention of serving "third" markets with exports of final goods from the affiliate in the host country*, and *the MNE will choose the most preferred destination market*. In short, pure HFDI is not related to the proximity of third countries, and export-platform FDI is negatively related to it. Thus when investigating the relationship of third-country proximity, we can differentiate complex VFDI from pure HFDI and export-platform FDI.

One may worry about the impact of border costs on pure HFDI, which is also discussed in Blonigen et al. (2007). Suppose there are ten countries, five of which have relatively large demand but high border costs. Then, MNEs would invest to each of the five countries to get access to their demand. If the five countries geographically happen to be concentrated in a particular area, it would seem that such HFDI, as well as the complex VFDI, would have a positive relationship to the proximity of third countries. However, examining the relationship to factor price differentials enables us to successfully differentiate complex VFDI from such HFDI because the latter does not have any relationship to *third-country* factor price differentials. Thus, FDI having a positive relationship to both the proximity of third countries and the factor price differentials of third countries is without doubt complex VFDI.

4. Empirical Methodology

In section 2 we confirmed that most Japanese overseas affiliates in East Asia producing information and communication electronics equipment and electronic parts and devices can be categorized as complex VFDI. Indeed, East Asia seems to be potentially the most suitable region for the development of complex VFDI since it consists of countries with different stages of economic development. Furthermore, under information technology agreements, the general tariff rates for those sectors are low or zero. Thus the necessary conditions for the development of complex VFDI are well satisfied in those sectors in East Asia. In the following sections we empirically investigate whether or not Japanese FDI to East Asia in those sectors has the above-discussed characteristics of complex VFDI. In this section we will explain our empirical methodology.

Based on our model, in complex VFDI, the production activity of affiliates in a given country is positively related to that of affiliates in neighboring countries having large differences in factor prices with the given country. Therefore we will examine the relationship between the activity of each affiliate and the activity of affiliates located in other East Asian countries and belonging to the same parent firm. If the above two testable hypotheses are correct, we should find a positive relationship in both geographical proximity and gap in factor prices in Japanese FDI to East Asia. Our analysis will focus on firms in information and communication electronics equipment and electronic parts and devices, industries in which most Japanese overseas affiliates in East Asia can be classified as complex VFDI, as pointed out in section 2.

We employ spatial econometric techniques in order to enable us to incorporate the activity of affiliates in third countries into our empirical framework. Although we lose a great degree of freedom by adding the activity variables in each third country separately as explanatory variables, a spatial-lag model can analyze the above-discussed relationships without losing any degree of freedom. Our spatial-lag model is as follows. Let Y_{it}^{j} denote a log of sales for the affiliate of firm $j \in \{1, \ldots, m\}$ in country

$i \in \{1,\ldots,9\}$ in year $t \in \{1994,\ldots,2003\}$. Our sample countries are nine economies: the Republic of Korea, China, Taiwan, Hong Kong, the Philippines, Thailand, Malaysia, Singapore, and Indonesia. In order to control to some extent for the disparity in MNE overseas experience, we restrict our sample to the MNEs that always had at least one affiliate in East Asia during the period 1994-2003. This gave us a sample having 90*m* observations, i.e. (*m* MNEs) * (9 countries) * (10 years) observations.

The spatial-lag equation we estimate first is:

$$\mathbf{Y} = \rho_D \, \mathbf{W}_D\mathbf{Y} + \rho_G \, \mathbf{W}_G\mathbf{Y} + \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon}.$$

Y is an N×1 vector, where N = 90*m*. **X** includes standard variables in the pure VFDI theory: wages, country risk, geographical distance from Japan (home country). **ε** is a vector of disturbances. $\mathbf{W}_D$ and $\mathbf{W}_G$ are weighting matrices and are constructed as follows:

$$\mathbf{W}_{Dj}^{t} = \begin{bmatrix} 0 & d_{1,2}^{t} & \cdots & d_{1,9}^{t} \\ d_{2,1}^{t} & 0 & \ddots & \vdots \\ \vdots & \ddots & 0 & d_{8,9}^{t} \\ d_{9,1}^{t} & \cdots & d_{9,8}^{t} & 0 \end{bmatrix}, \mathbf{W}_{Dj} = \begin{bmatrix} W_{Dj}^{1994} & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & W_{Dj}^{2003} \end{bmatrix}, \mathbf{W}_{D} = \begin{bmatrix} W_{D1} & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & W_{Dm} \end{bmatrix},$$

$$\mathbf{W}_{Gj}^{t} = \begin{bmatrix} 0 & g_{1,2}^{t} & \cdots & g_{1,9}^{t} \\ g_{2,1}^{t} & 0 & \ddots & \vdots \\ \vdots & \ddots & 0 & g_{8,9}^{t} \\ g_{9,1}^{t} & \cdots & g_{9,8}^{t} & 0 \end{bmatrix}, \mathbf{W}_{Gj} = \begin{bmatrix} W_{Gj}^{1994} & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & W_{Gj}^{2003} \end{bmatrix}, \mathbf{W}_{G} = \begin{bmatrix} W_{G1} & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & W_{Gm} \end{bmatrix},$$

where $d^{t}_{i,k}$ and $g^{t}_{i,k}$ are the geographical proximity (inverse of distance) and the wage gap between countries *i* and *k* in year *t*, respectively. Since distances are time-invariant, $\mathbf{W}_{Dj}^{1994} = \mathbf{W}_{Dj}^{1995} = \ldots = \mathbf{W}_{Dj}^{2003}$. Each weighting matrix is symmetric and row-normalized. Contrary to Blonigen el al. (2007), our equation has two kinds of weighting matrices. We call such an equation a “multiple spatial-lag model”.

As is well known, ordinary least squares estimates (OLS estimates) are biased as well as inconsistent for the parameters of the spatial model. Our multiple spatial-lag model is also no exception. By rewriting the above equation as:

$$\mathbf{Y} = \mathbf{Z}\boldsymbol{\rho} + \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon},$$

where $\mathbf{Z} = [\mathbf{W}_D\mathbf{Y}, \mathbf{W}_G\mathbf{Y}]$ and $\boldsymbol{\rho} = [\rho_D, \rho_G]'$, we can express our OLS estimate $\boldsymbol{\gamma}_{\mathrm{OLS}}$ for $\boldsymbol{\rho}$ as:

$$\boldsymbol{\gamma}_{\mathrm{OLS}} = \boldsymbol{\rho} + [\mathbf{Z'MZ}]^{-1} \, \mathbf{Z'M}\boldsymbol{\varepsilon},$$

where $\mathbf{M} = \mathbf{I} - \mathbf{X}(\mathbf{X'X})^{-1}\mathbf{X'}$. The expected value of the second term is not equal to zero, therefore the OLS estimate is biased. Furthermore, while the probability limit of $N^{-1}(\mathbf{Z'MZ})$ can be a finite and nonsingular matrix, that of $N^{-1}(\mathbf{Z'M}\boldsymbol{\varepsilon})$ is not equal to zero. Thus, the OLS estimate is not only biased but also inconsistent. To obtain consistent estimators, we perform a two-stage least squares (2SLS). Following Kelejian and Prucha (1998) and Dow (2007), we use **X**, $\mathbf{W}_D\mathbf{X}$, and $\mathbf{W}_G\mathbf{X}$ as instruments for $\mathbf{W}_D\mathbf{Y}$ and $\mathbf{W}_G\mathbf{Y}$. Our 2SLS estimate $\boldsymbol{\gamma}_{2SLS}$ for $\boldsymbol{\rho}$ is given by:

$$\boldsymbol{\gamma}_{2SLS} = [\mathbf{Z'H(H'H)}^{-1}\mathbf{H'MH(H'H)}^{-1}\mathbf{H'Z}]^{-1}\ [\mathbf{Z'H(H'H)}^{-1}\mathbf{H'MY}]$$

where $\mathbf{H} = [\mathbf{X}, \mathbf{W}_D\mathbf{X}, \mathbf{W}_G\mathbf{X}]$, instrument matrix. The significantly positive sign of ρ_D and ρ_G implies that production activity in each affiliate is positively related to that in affiliates in neighboring countries with large differences in factor prices, as our model of complex VFDI predicts.

We will turn next to examining if the type of VFDI depends on firm productivity or not. We will do this by estimating the following equation:

$$\mathbf{Y} = \rho_D\,(\mathbf{I} + \lambda_D\,\mathbf{A})\mathbf{W}_D\mathbf{Y} + \rho_G\,(\mathbf{I} + \lambda_G\,\mathbf{A})\mathbf{W}_G\mathbf{Y} + \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon},$$

where **I** is the square matrix with ones on the main diagonal and zeros elsewhere (identity matrix), and:

$$\mathbf{A} = \begin{bmatrix} \begin{bmatrix} a_1^{1994}I & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & a_1^{2003}I \end{bmatrix} & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & \begin{bmatrix} a_m^{1994}I & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & a_m^{2003}I \end{bmatrix} \end{bmatrix}.$$

a_j^t denotes productivity in firm *j* in year *t*. As argued above, if all Japanese firms' FDI to East Asia is complex VFDI, the sign of both ρ_D and ρ_G should be positive. On the other hand, if all Japanese firms' FDI to East Asia is pure VFDI, in which an MNE selects *one* country with the lowest production costs, affiliate activities would not have any spatial relationship, i.e., ρ_D and ρ_G are estimated to be insignificant. Thus, as illustrated in the previous section, if firms with high productivity are likely to perform complex VFDI and firms with low productivity tend to perform pure VFDI, the estimation of both λ_D and λ_G should be significantly positive.

Our data sources are as follows. As in section 2, we use the micro database of SOBA for affiliate sales. The aim of SOBA is to obtain basic information on the activities of the foreign affiliates of Japanese firms. The survey covers all Japanese firms that have affiliates abroad. The main information in SOBA includes such items as the year of affiliate establishment, the breakdown of sales and purchases, employment, costs, and research and development. (For more information on the items in SOBA, see

"Survey Form for Oversea Affiliates" and "Guide for Completing the Survey"[6]). Regarding the sources of the regressors, data on the average wages in each country are estimated by aggregating the affiliate-level wage data in SOBA. The country risk index is drawn from "Institutional Investor: International edition" (Institutional Investor). This index is the aggregate evaluation of bankers on the risk of default; the larger the index the lower the risk of a country defaulting. Data on distance are drawn from the CEPII website.[7] The data on GDP and GDP deflator for each country can be obtained from "World Development Indicators" (World Bank). Those for Taiwan are from the "Statistical Yearbook of the Republic of China" (Taipei: Directorate-Genral of Budget, Accounting and Statistics, Executive Yuan, Republic of China).

We use firms' TFP as the measurement of their productivity, data for which were drawn from METI's *Kigyou Katsudou Kihon Chousa Houkokusho* (*Results of the Basic Survey of Japanese Business Structure and Activities*, hereafter BSJBSA).[8] From this data we estimate the TFP index following Caves et al. (1982, 1983) and Good et al. (1983). The TFP index is calculated as follows:

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

where Q_{it}, s_{ift} and X_{ift} denote the shipments of firm *i* in year *t*, the cost share of input *f* for firm *i* in year *t*, and input of factor *f* for firm *i* in year *t*, respectively. The inputs are labor, capital, and intermediates. Variables with an upper bar denote the industry average for that variable. We define a hypothetical (representative) firm for each year and industry. Its input and output are calculated as the geometric means of the input and output of all establishments in the industry. The first two terms on the right-hand side of the equation denote the cross-sectional TFP index based on the Theil-Tornqvist specification for each firm and year relative to the hypothetical establishment. Since the cross-sectional TFP indexes for *t* and *t*-1 are not comparable, we adjust the cross-sectional TFP index with the TFP growth rate of the hypothetical firm, which is represented by the third and fourth terms in the equation. For more details on the construction of these variables, see Appendix B.

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6 Downloadable from the METI web site: http://www.meti.go.jp/english/statistics/tyo/kaigaizi/index.html.

7 http://www.cepii.fr/anglaisgraph/bdd/distances.htm.

8 This survey was first conducted in 1991, then in 1994, and annually thereafter. The survey covers all firms, both manufacturing and non-manufacturing, with more than 50 employees and capitalized at more than 30 million yen.

5. Empirical Results

This section reports the regression results from examination of the above two testable hypotheses. The correlation matrix is shown in Table 6.

== Table 6 ==

The regression results for the first hypothesis are provided in Table 7. We performed not only a 2SLS estimation but also an OLS one. First, the results for the standard bilateral variables look good. Coefficients for country risk and wages have the expected sign, positive for country risk and negative for wages. These results indicate that Japanese MNEs seek out the low-wage and low-risk countries in East Asia as the pure VFDI theory predicts. In particular, one may say that country risk partly embodies the set-up costs of affiliates. If this argument is correct, the significantly positive coefficient for country risk implies that low plant set-up costs are surely one of the major determinants of Japanese VFDI. On the other hand, the sign of the coefficients for both GDP and distance from Japan are not what we had expected. Second, the coefficients for weighting matrices, where our interest lies, are significantly estimated with the expected sign in the OLS estimation of (1). The positive coefficients of both matrices imply that the affiliates belonging to *each* Japanese MNE are linked with one another through proximity and wage differentials. In other words, we can say that the mechanics of complex VFDI work in Japanese FDI to East Asia. But, such results worsen in the 2SLS estimation. The coefficient for the proximity matrix turns out to be insignificant. This result seems to be due to the high correlation between the two matrices, i.e. multi-colinearity. Indeed, as in Table 5, such correlation is 0.80. By introducing the two matrices separately, we get significantly positive 2SLS coefficients for both matrices.

== Table 7 ==

The regression results for the second hypothesis are provided in Table 8. To decrease the pairs of variables with high correlation, i.e., to avoid the multi-colinearity problem, we drop some weighting matrix-related variables. First, we eliminate the proximity and gap matrices. The omission of these variables does not lead to omitted-variable bias since their coefficients show correlation in the case of pure VFDI (i.e. zero) once we introduce their products to firm productivity. The results are in column (4). Both the OLS and 2SLS estimates have the expected signs though the coefficients for the interaction terms are insignificant in the 2SLS estimate. Next, as an extreme, we introduce each weighting matrix-related variable separately; the results are shown in columns (5) and (6). Both of the coefficients for their products to TFP are estimated as significantly positive, indicating that MNEs with higher productivity are more likely to be engaged in complex VFDI than those with lower productivity.

== Table 8 ==

Next, we perform two robustness checks. First, our specification for a dependent variable may yield an unexpected downward bias in coefficients for weighting matrices when the FDI type changes from pure VFDI to complex VFDI. From the theoretical point of view, such a change not only gives rise to new observations with non-zero sales but also may decrease the sales of observations which had non-zero sales in pure VFDI. Using the terminology in section 3, we can say that such a change may decrease the product sales of affiliates in country 2 although sales turn out to be positive for affiliates in country 3. This decrease would give rise to a downward bias in coefficients for weighting matrices. To avoid such a bias as easily as possible, we use as a dependent variable a binary variable, which takes unity if a firm locates an affiliate in a region (i.e. if the previous dependent variable has positive values) and zero otherwise. Here we employ a probit estimation technique which in a spatial context is examined in Beron and Vijverberg (2004).We use Newey's (1987) minimum chi-squared estimator in particular to obtain consistent estimators (IVProbit). The results are shown in Tables 9 and 10 and are unchanged from the baseline results.

== Tables 9 and 10 ==

Second, we restrict our sample only to affiliates categorized as VFDI in section 2. This restriction is natural in order to shed light on the contrast in mechanics between pure and complex VFDI. As argued in section 3, positive estimates of the weighting matrices should emerge only in complex VFDI. But the estimates of these matrices still suffer from unexpected bias if the sample includes affiliates categorized as other than VFDI, e.g. HFDI. Thus, to focus on the contrast between pure and complex VFDI, the sample here is restricted to the affiliates categorized as VFDI. The results are provided in Tables 11 and 12, being qualitatively unchanged from the baseline results. In sum, we can again confirm the validity of the mechanics of complex VFDI in Japanese FDI to East Asian countries and that MNEs with high productivity are more likely to be engaged in complex VFDI.

== Tables 11 and 12 ==

6. Concluding Remarks

In this paper we statistically tested the validity of the mechanics of complex VFDI in Japanese machinery FDI to East Asia. Our model showed that in complex VFDI, the production activity of affiliates in a given country is positively related to that in neighboring countries which have large differences in factor prices with the given country. Furthermore, we showed that firms with high productivity are likely to choose a complex VFDI strategy rather than one based on pure VFDI. On this basis, we estimated a multiple spatial-lag model for Japanese machinery FDI to East Asia. Our empirical results showed that the mechanics of complex VFDI work in Japanese FDI to East Asia and that these mechanics work more strongly in the MNEs with higher productivity.

Our results tell us an important implication for the policies of developing countries to attract MNEs. Policy makers in developing countries have been afraid of the drain of multinational firms to other developing countries with lower wages. In the ASEAN countries, for example, policy makers tend to perceive China as a potential threat. To deter the drain of MNEs from their countries, these policy makers believe it is crucial to reduce trade and investment barriers to potential investor countries such as Japan and the U.S. However, our results indicate that they should reduce the barriers not only to the investor countries but also to the countries that they regard as a threat. In short, it is important for countries with *medium*-level economic development to become hub-countries in international production networks.

Appendix A. Country List in Tables 1-4

North America	Asia	Europe
Canada	Bangladesh	Austria
United States	China	Belgium
	Hong Kong, China	CIS
	India	Czech
	Indonesia	Denmark
	Korea, Rep.	Finland
	Malaysia	France
	Myanmar	Germany
	Pakistan	Hungary
	Philippines	Ireland
	Singapore	Italy
	Sri Lanka	Netherlands
	Taiwan	Poland
	Thailand	Portugal
	Vietnam	Rumania
		Russian Federation
		Slovakia
		Spain
		Sweden
		Switzerland
		Turkish
		United Kingdom
		Yugoslavia

Appendix B. Construction of Variables Used for the TFP Index

Output, intermediate input, labor input, and deflators

Real gross output is measured as sales deflated by the output deflator, while intermediate input is the cost of materials deflated by the input deflator. Labor input is measured by the total number of employees. All output and input deflators were obtained from the JIP Database 2008 (Fukao et al., 2006).

Capital stock

Following Fukao et al. (2006), we used for the capital stock the nominal book values of tangible assets by multiplying the ratio of the net stock with the book value of industry-level capital. Net capital stocks by industry are from the JIP Database 2008, while the book values of capital by industry were obtained by aggregating the individual data from the *Financial Statement Statistic of Corporations by Industry*.

Cost shares

To construct the TFP index, we needed the ratios of labor costs, intermediate input costs, and capital costs to total costs. We calculated labor costs as total salaries and intermediate input costs as the sum of raw materials, fuel, electricity and subcontracting expenses for consigned production. Capital costs were calculated by multiplying the real net capital stock with the user cost of capital, P_K. The latter was estimated as follows:

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

where P_I is the price of investment goods, r the interest rate, and δ the depreciation rate. Data on the price of investment goods and the depreciation rate were calculated using the investment and capital stock matrices from the JIP Database 2008.[9] Interest rates (10-year-bond yields) are from the Bank of Japan.

[9] The JIP Database provides investment and capital stock matrices by industry and assets for 108 industries and 39 types of assets. We calculated the weighted averages of price indices for investment goods and the depreciation rates by industry.

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Table 1. The Average Number of Affiliates by Region, Parent Size, and Parent Industry

	Affiliates in North America				Affiliates in Asia				Affiliates in Europe			
Parent size	Small	Medium	Large	Total	Small	Medium	Large	Total	Small	Medium	Large	Total
1995												
General machinery	1.00	1.17	1.28	1.20	1.21	1.81	2.52	2.03	1.00	1.00	2.50	2.00
Electronic machinery and equipment	1.00	1.00	1.20	1.15	1.20	1.33	3.27	2.50	1.00		1.79	1.69
Information and communication devices	1.00	1.10	1.06	1.06	1.41	2.20	3.87	2.73	1.00	1.25	2.48	2.10
Automobiles	1.00	1.00	1.12	1.08	1.00	1.25	2.78	2.31		1.00	1.96	1.92
Transport equipment		1.00	1.00	1.00		2.00	1.75	1.80			2.00	2.00
Precision instruments	1.00	1.00	1.13	1.09	1.33	1.11	1.67	1.38	2.00	1.00	1.25	1.30
Wholesale of machinery products	1.00	1.00	1.22	1.13	1.75	1.67	4.30	2.67	1.00	1.25	2.71	2.08
1998												
General machinery	1.09	1.18	1.32	1.23	1.33	1.90	2.91	2.17		1.17	2.52	2.06
Electronic machinery and equipment	1.00	1.00	1.21	1.15	1.38	1.83	3.30	2.47	1.00	1.00	2.00	1.80
Information and communication devices	1.00	1.10	1.17	1.14	1.63	1.92	4.24	2.80	1.00	1.33	2.56	2.19
Automobiles	1.00	1.10	1.12	1.11	1.71	1.58	3.43	2.59	1.00	1.00	2.03	1.84
Transport equipment		1.00	1.00	1.00	1.00	1.00	2.50	1.38		1.00	4.00	2.50
Precision instruments	1.00	1.00	1.00	1.00	1.14	1.27	2.56	1.67	2.00		2.00	2.00
Wholesale of machinery products	1.00	1.00	1.45	1.26	1.71	1.83	4.67	2.70	1.00	1.50	4.09	3.12
2001												
General machinery	1.07	1.11	1.19	1.13	1.47	2.00	2.68	2.04	1.00	1.22	2.36	1.81
Electronic machinery and equipment	1.00	1.00	1.07	1.04	1.25	1.83	3.80	2.57	1.00	1.67	1.71	1.63
Information and communication devices	1.00	1.07	1.11	1.08	1.79	2.33	4.17	3.02	1.67	1.00	2.36	2.00
Automobiles	1.00	1.07	1.15	1.11	1.29	1.47	3.79	2.74	1.00	1.00	1.95	1.82
Transport equipment	1.00		1.00	1.00	2.00	1.00	2.20	1.78			2.50	2.50
Precision instruments	1.00	1.00	1.00	1.00	1.17	1.46	2.10	1.62	2.00		2.13	2.11
Wholesale of machinery products	1.00	1.00	1.43	1.20	1.37	2.67	5.15	2.83	1.00	1.25	4.33	3.21

Source: Authors' calculation

Note: Parent size is measured by the number of employees, and "Small", "Medium", and "Large" indicates firms with less than 300 employees, more than 300 and less than 1,000 employees, and more than 1,000 employees, respectively.

Table 2. The Ratio of VFDI Affiliates to All Affiliates by Affiliate Industry

	NAmerica	Asia	Europe
1995			
General machinery	10%	32%	10%
Electronic machinery and equipment	18%	42%	20%
Information and communication devices	38%	57%	23%
Transport equipment	16%	24%	23%
Precision instruments	34%	63%	40%
1998			
General machinery	18%	41%	22%
Electronic machinery and equipment	18%	46%	13%
Information and communication devices	26%	62%	20%
Transport equipment	13%	32%	16%
Precision instruments	49%	64%	58%
2001			
General machinery	21%	43%	23%
Electronic machinery and equipment	18%	47%	22%
Information and communication devices	22%	58%	16%
Transport equipment	21%	36%	19%
Precision instruments	22%	55%	20%

Source: Authors' calculation

Table 3. The Ratio of Complex VFDI Affiliates to All VFDI Affiliates by Affiliate Industry

	NAmerica	Asia	Europe
1995			
General machinery	25%	31%	20%
Electronic machinery and equipment	0%	36%	0%
Information and communication devices	8%	39%	6%
Transport equipment	7%	14%	5%
Precision instruments	0%	32%	6%
1998			
General machinery	4%	27%	4%
Electronic machinery and equipment	9%	36%	0%
Information and communication devices	4%	37%	3%
Transport equipment	11%	16%	5%
Precision instruments	8%	32%	8%
2001			
General machinery	17%	20%	7%
Electronic machinery and equipment	8%	40%	0%
Information and communication devices	6%	42%	14%
Transport equipment	5%	21%	4%
Precision instruments	0%	31%	20%

Source: Authors' calculation

Table 4. The Ratio of Complex VFDI-Type Affiliates to VFDI-Type Affiliates by Parent Size

	NAmerica	Asia	Europe
1995			
Small Firms	22%	35%	0%
Large Firms	7%	33%	7%
1998			
Small Firms	6%	30%	0%
Large Firms	8%	32%	4%
2001			
Small Firms	15%	31%	14%
Large Firms	6%	35%	7%

Source: Authors' calculation

Note: The terms "Small Firms" and "Large Firms" denote those with less than 1,000 employees and more than 1,000 employees, respectively.

Table 5. The Ratio of Complex VFDI-Type Affiliates to VFDI-Type Affiliates by Parent Productivity

	NAmerica	Asia	Europe
1995			
Less Productive Firms	14%	36%	14%
More Productive Firms	4%	31%	3%
1998			
Less Productive Firms	11%	25%	5%
More Productive Firms	5%	36%	n.a.
2001			
Less Productive Firms	7%	31%	7%
More Productive Firms	8%	38%	12%

Source: Authors' calculation

Note: The terms "Less Productive Firms" and "More Productive Firms" denote those with less than and more than the median of all VFDI firms, respectively. "n.a." means "not available".

Table 6. Correlation Matrix

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Y	(1)	1							
GDP	(2)	0.00	1						
Risk	(3)	0.08	0.54	1					
Distance from JPN	(4)	0.03	-0.66	-0.26	1				
Wages	(5)	-0.01	0.54	0.70	-0.29	1			
$\mathbf{W_D Y}$	(6)	0.30	-0.01	-0.03	0.02	0.04	1		
$\mathbf{W_G Y}$	(7)	0.25	-0.01	-0.07	-0.01	0.01	0.80	1	
$\mathbf{AW_D Y}$	(8)	0.30	-0.01	-0.03	0.02	0.05	0.98	0.79	1
$\mathbf{AW_G Y}$	(9)	0.26	-0.01	-0.07	-0.01	0.02	0.79	0.97	0.83

Table 7. Baseline Results: Hypothesis 1

	(1)		(2)		(3)	
Estimation Method	OLS	2SLS	OLS	2SLS	OLS	2SLS
Explanatory Variables						
GDP	-0.01	-0.012	-0.01	-0.009	-0.011	-0.012
	[0.008]	[0.008]	[0.008]	[0.008]	[0.008]	[0.008]
Risk	0.417***	0.461***	0.414***	0.444***	0.421***	0.468***
	[0.017]	[0.018]	[0.017]	[0.018]	[0.017]	[0.018]
Distance from JPN	0.019**	0.028***	0.017**	0.012	0.028***	0.031***
	[0.008]	[0.010]	[0.008]	[0.009]	[0.009]	[0.009]
Wages	-0.113***	-0.119***	-0.114***	-0.127***	-0.107***	-0.118***
	[0.006]	[0.007]	[0.006]	[0.006]	[0.006]	[0.006]
Weighting Matrices						
Proximity	0.488***	0.143	0.542***	0.944***		
	[0.021]	[0.221]	[0.012]	[0.031]		
Gap	0.073***	0.802***			0.492***	0.987***
	[0.022]	[0.223]			[0.014]	[0.032]
Observation	18,180	18,180	18,180	18,180	18,180	18,180

Notes: Standard errors are in parentheses. ***, **, and * show 1%, 5%, and 10% significant, respectively. Year dummies are added.

Table 8. Baseline Results: Hypothesis 2

	(4)		(5)		(6)	
Estimation Method	OLS	2SLS	OLS	2SLS	OLS	2SLS
Explanatory Variables						
GDP	-0.01	-0.01	-0.009	-0.01	-0.011	-0.011
	[0.008]	[0.008]	[0.008]	[0.008]	[0.008]	[0.008]
Risk	0.415***	0.401***	0.412***	0.401***	0.419***	0.416***
	[0.017]	[0.018]	[0.017]	[0.017]	[0.017]	[0.018]
Distance from JPN	0.019**	0.021**	0.018**	0.020**	0.028***	0.027***
	[0.008]	[0.009]	[0.008]	[0.008]	[0.008]	[0.008]
Wages	-0.112***	-0.107***	-0.113***	-0.108***	-0.107***	-0.106***
	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]
Weighting Matrices						
*TFP * Proximity*	0.396***	0.258	0.445***	0.317***		
	[0.018]	[0.162]	[0.010]	[0.032]		
*TFP * Gap*	0.064***	0.046			0.412***	0.380***
	[0.019]	[0.175]			[0.011]	[0.035]
Observation	18,180	18,180	18,180	18,180	18,180	18,180

Notes: Standard errors are in parentheses. ***, **, and * show 1%, 5%, and 10% significant, respectively. Year dummies are added.

Table 9. Probit Results: Hypothesis 1

	(1)		(2)		(3)	
Estimation Method	Probit	IVProbit	Probit	IVProbit	Probit	IVProbit
Explanatory Variables						
GDP	-0.023	-0.031	-0.021	-0.019	-0.032	-0.035
	[0.025]	[0.027]	[0.025]	[0.026]	[0.025]	[0.026]
Risk	1.409***	1.555***	1.397***	1.496***	1.406***	1.560***
	[0.059]	[0.064]	[0.059]	[0.061]	[0.059]	[0.062]
Distance from JPN	0.076***	0.113***	0.071**	0.056*	0.110***	0.119***
	[0.028]	[0.033]	[0.028]	[0.029]	[0.028]	[0.029]
Wages	-0.380***	-0.393***	-0.379***	-0.421***	-0.356***	-0.392***
	[0.019]	[0.022]	[0.019]	[0.021]	[0.019]	[0.020]
Weighting Matrices						
Proximity	1.429***	0.063	1.575***	2.844***		
	[0.066]	[0.739]	[0.040]	[0.103]		
Gap	0.194***	2.784***			1.419***	2.949***
	[0.070]	[0.745]			[0.042]	[0.104]
Observation	18,180	18,180	18,180	18,180	18,180	18,180

Notes: Standard errors are in parentheses. ***, **, and * show 1%, 5%, and 10% significant, respectively. Year dummies are added.

Table 10. Probit Results: Hypothesis 2

	(4)		(5)		(6)	
Estimation Method	Probit	IVProbit	Probit	IVProbit	Probit	IVProbit
Explanatory Variables						
GDP	-0.022	-0.024	-0.02	-0.023	-0.032	-0.032
	[0.025]	[0.026]	[0.025]	[0.026]	[0.025]	[0.025]
Risk	1.403***	1.361***	1.391***	1.356***	1.404***	1.394***
	[0.059]	[0.063]	[0.059]	[0.060]	[0.059]	[0.060]
Distance from JPN	0.077***	0.091***	0.072***	0.080***	0.110***	0.110***
	[0.028]	[0.032]	[0.028]	[0.028]	[0.028]	[0.028]
Wages	-0.376***	-0.355***	-0.376***	-0.359***	-0.356***	-0.353***
	[0.019]	[0.020]	[0.019]	[0.020]	[0.019]	[0.020]
Weighting Matrices						
*TFP * Proximity*	1.153***	0.54	1.286***	0.890***		
	[0.057]	[0.540]	[0.032]	[0.104]		
*TFP * Gap*	0.171***	0.324			1.184***	1.102***
	[0.060]	[0.586]			[0.034]	[0.112]
Observation	18,180	18,180	18,180	18,180	18,180	18,180

Notes: Standard errors are in parentheses. ***, **, and * show 1%, 5%, and 10% significant, respectively. Year dummies are added.

Table 11. Regression Results for VFDI Affiliates: Hypothesis 1

	(1)		(2)		(3)	
Estimation Method	OLS	2SLS	OLS	2SLS	OLS	2SLS
Explanatory Variables						
GDP	-0.278***	-0.318***	-0.261***	-0.260***	-0.315***	-0.347***
	[0.078]	[0.082]	[0.079]	[0.080]	[0.079]	[0.082]
Risk	3.590***	3.856***	3.541***	3.755***	3.618***	3.924***
	[0.176]	[0.184]	[0.176]	[0.181]	[0.178]	[0.185]
Distance from JPN	0.354***	0.437***	0.293***	0.191**	0.527***	0.555***
	[0.088]	[0.118]	[0.087]	[0.090]	[0.088]	[0.091]
Wages	-1.114***	-1.070***	-1.167***	-1.293***	-0.951***	-0.965***
	[0.062]	[0.095]	[0.062]	[0.064]	[0.062]	[0.064]
Weighting Matrices						
Proximity	0.455***	0.300	0.608***	0.931***		
	[0.027]	[0.200]	[0.014]	[0.027]		
Gap	0.190***	0.653***			0.604***	0.989***
	[0.028]	[0.206]			[0.015]	[0.028]
Observation	11,430	11,430	11,430	11,430	11,430	11,430

Notes: Standard errors are in parentheses. ***, **, and * show 1%, 5%, and 10% significant, respectively. Year dummies are added.

Table 12. Regression Results for VFDI Affiliates: Hypothesis 2

	(4)		(5)		(6)	
Estimation Method	OLS	2SLS	OLS	2SLS	OLS	2SLS
Explanatory Variables						
GDP	-0.272***	-0.289***	-0.256***	-0.259***	-0.310***	-0.302***
	[0.079]	[0.082]	[0.079]	[0.080]	[0.079]	[0.080]
Risk	3.560***	3.411***	3.517***	3.366***	3.588***	3.507***
	[0.176]	[0.186]	[0.177]	[0.182]	[0.178]	[0.183]
Distance from JPN	0.368***	0.490***	0.313***	0.381***	0.521***	0.514***
	[0.088]	[0.112]	[0.087]	[0.090]	[0.088]	[0.088]
Wages	-1.104***	-0.959***	-1.153***	-1.064***	-0.953***	-0.948***
	[0.062]	[0.091]	[0.062]	[0.066]	[0.062]	[0.063]
Weighting Matrices						
*TFP * Proximity*	0.365***	0.038	0.489***	0.294***		
	[0.023]	[0.161]	[0.011]	[0.044]		
*TFP * Gap*	0.150***	0.263			0.486***	0.398***
	[0.024]	[0.170]			[0.012]	[0.047]
Observation	11,430	11,430	11,430	11,430	11,430	11,430

Notes: Standard errors are in parentheses. ***, **, and * show 1%, 5%, and 10% significant, respectively. Year dummies are added.

Figure 1. Domestic Production and Pure VFDI to Country 2

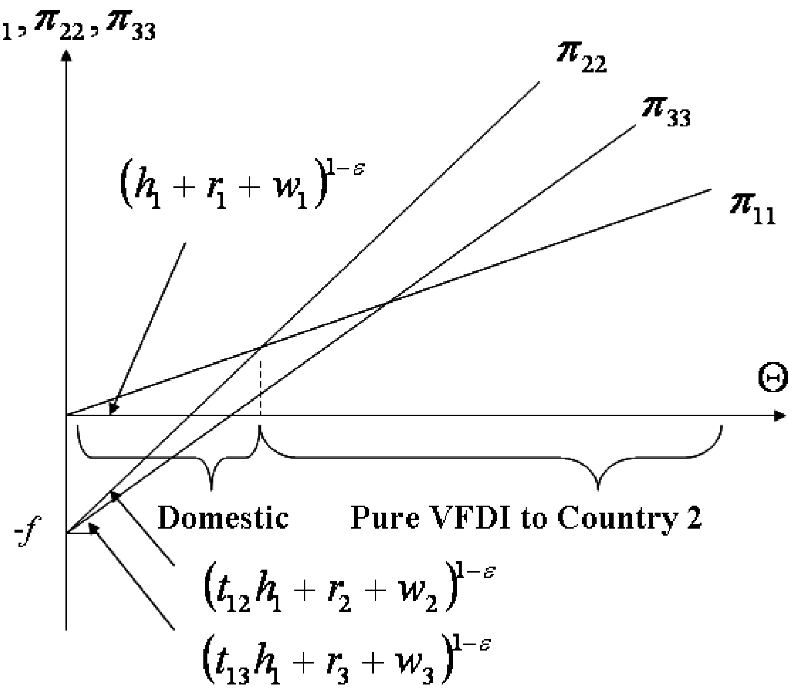

Figure 2. Domestic Production and Pure VFDI to Country 3

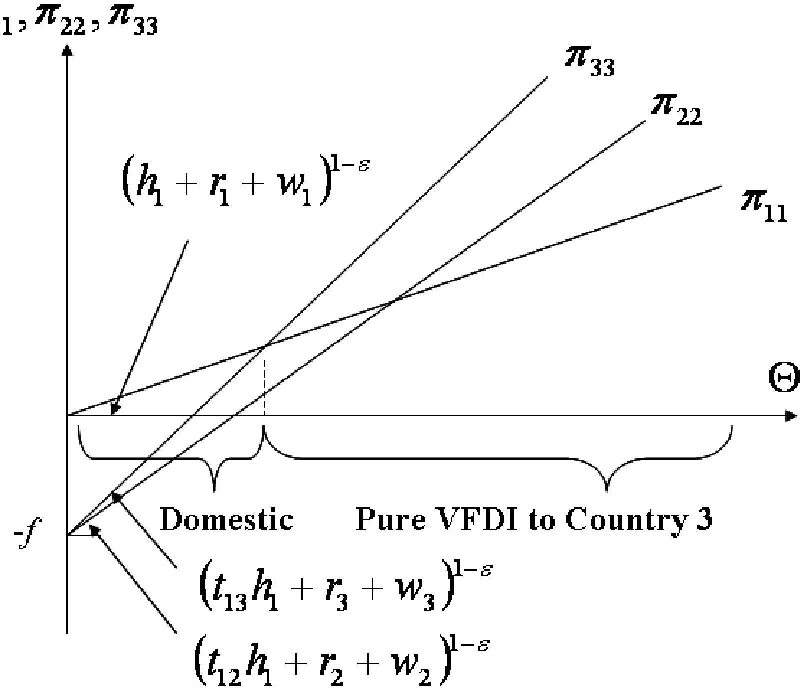

Figure 3. Domestic Production, Pure VFDI, and Complex VFDI

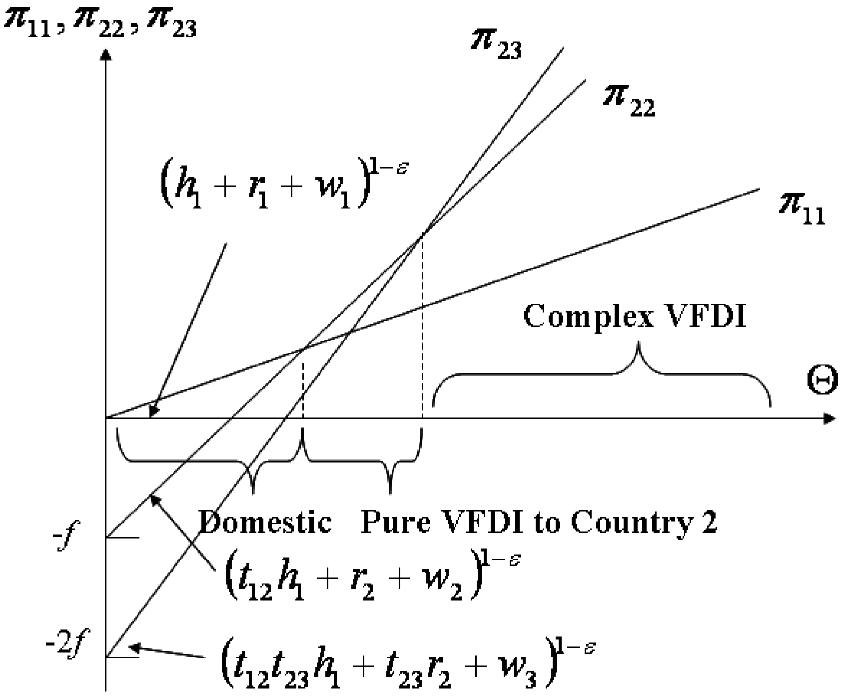

Figure 4. Domestic Production and Complex VFDI