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Innovation in the Host Country and the Structure of Foreign Direct Investment: Evidence from Japanese multinationals

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Innovation in the Host Country and the Structure of Foreign Direct Investment: Evidence from Japanese multinationals*

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Abstract

In this study, we investigate how the innovative performance of local firms in host countries affects the structure of foreign direct investment (FDI) by multinational enterprises (MNEs) using Japanese firm-level data and patent application data for host countries of Japanese FDI at the United States Patent and Trademark Office for the period from 1995 to 2006. The structure of FDI is measured by the shares of local transactions and transactions with the source country and a third country by foreign affiliates of Japanese MNEs. Our estimation results imply that innovation by local firms in the same and related industries in host countries in Asia and Europe strengthens forward and backward linkages. We also find that innovation in the host country encourages transactions with the source country when the former is technologically advanced. Finally, our findings suggest that, in Asia, the innovative performance of local firms contributes to the development of regional production networks.

Keywords: Innovation; Foreign direct investment; Fragmentation; Production network.

JEL classification: F23; O31

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1 Introduction

Foreign direct investment (FDI) has grown very quickly in the last decade, and multinational enterprises (MNEs) play a dominant role in international trade. In the trade and FDI literature, two basic FDI modes are *horizontal FDI* (Markusen, 1984) and *vertical FDI* (Helpman, 1984). In the former, production plants are duplicated in the home and foreign countries and each market is served from its domestic plant. Thus, this type of FDI is mainly motivated by market seeking and transport costs and trade cost savings. The latter involves the relocation of production plants from the home country to the foreign country (and possibly multiple foreign countries). This type of FDI is mainly motivated by efficiency seeking based on factor price differentials between the home and foreign countries.

However, in practice, very little FDI falls neatly into these standard categories (Baldwin and Okubo, 2012). Recent studies on FDI have proposed "hybrid" types of FDI. These hybrid types include *export-platform FDI* (Ekholm et al., 2007), *complex FDI* (Yeaple, 2003; Grossman et al., 2006), and *networked FDI* (Baldwin and Okubo, 2012). In the case of export-platform FDI, foreign affiliates serve the market in a third country. The motivation for this type of FDI can be understood as some combination of market and efficiency seeking. In complex FDI, MNEs conduct horizontal and vertical FDI at the same time. Finally, networked FDI is characterized as part of international production networks or global value chains (Baldwin and Okubo, 2012).

A number of empirical studies provide evidence of strong support for horizontal FDI (Brainard, 1997). However, Hanson et al. (2005) find evidence of vertical production networks in American MNEs. Alfaro and Charlton (2009) show that the share of vertical FDI is much higher than previously thought, even among developed countries. They argue that a significant amount of vertical FDI has been misclassified as horizontal in the literature. Moreover, Baltagi et al. (2007) find significant third-country effects and confirm that MNEs engage in various modes of complex FDI.

Several empirical studies on technology spillovers show that FDI is one of the most important channels of international technology spillovers. Many of these studies focus on spillovers resulting from inward FDI to local firms (Haskel et al., 2007; Keller and Yeaple, 2009; Todo, 2006; Todo and Miyamoto, 2006), but some studies find evidence of spillovers from local firms to MNEs (Branstetter, 2006; Singh, 2007). Moreover, Jinji et al. (2011) demonstrate that the degree of technology spillovers between MNEs and local firms in the host country depends on the structure of FDI. In this study, we go one step further to investigate how innovation by local firms in the host country affects the structure of FDI. To our knowledge, no existing study has examined this issue.

The reason that we need to pay attention to innovation by local firms in the host country is partly derived from the observation that innovative activities in emerging economies have been increasing. Innovative activities used to be concentrated in a small number of countries in the world. For example, Eaton and Kortum (1996) estimate innovation and technology diffusion among 19 OECD countries and find that each OECD country other than the US obtains more than half of its productivity growth from technological knowledge that originated abroad. They also find that more than half of the growth in every OECD country is derived from innovation in the US, Japan, and Germany. Eaton and Kortum (1999) also find that research performed abroad is about two-thirds as potent as domestic research in the five leading research economies, that is, the US, Japan, Germany, the UK, and France. Their finding suggests that the US and Japan jointly contribute to over 65 percent of growth in each of the five countries. However, innovative activities in emerging economies have been increasing in the last two decades. Figure 1 shows patent applications at the United States Patent and Trademark Office (USPTO) from 1995 to 2006. It is clear that the US is the dominant player in the world's innovative activities. Japan and the Western European countries, such as Germany, France, and the UK, have also been major players at the USPTO. As is indicated in the figure, there is a significant increase in the number of patent applications from East Asian countries (excluding Japan) during this period. In 1995, the share of patent applications from East Asian countries at the USPTO was only 2.5 percent, but it reached 10 percent in 2006.

Therefore, the main purpose of this study is to investigate how the innovative performance of local firms in the same and related industries in the host countries affects the structure of FDI. We attempt to approach this issue by utilizing detailed data on the foreign affiliates of Japanese MNEs and patent applications of host countries at the USPTO. We measure the structure of FDI based on sales and purchases of foreign affiliates of Japanese MNEs.[1] In particular, our dataset allows us to measure the shares of local transactions, transactions with the source country (i.e., Japan), and transactions with third countries in the sales and purchases of foreign affiliates. We estimate how these shares are affected by the innovative performance of local firms in the host country. The innovative performance of local firms is measured by the number of patent applications at the USPTO. To control for the motivations behind horizontal FDI, we calculate the number of patent applications per real GDP and use it as our main explanatory variable. We also investigate regional heterogeneity in the effect in question.

Our main findings are as follows. First, we find that innovation in the host country significantly increases the share of local transactions in both sales and purchases in European and Asian countries, whereas no such effect is observed in the US. Second, innovative activities by local firms encourage transactions with the source country when the host country is technologically advanced, that is, the US and European countries. However, this type of effect is not observed in Asian countries. Third, innovation in the host country also enhances the export-platform type of FDI in the US and Asian countries. We check the robustness of these findings by implementing alternative estimations. Finally, innovation by local firms increases the share of transactions within the region in Asia, whereas no such

[1] As done in this study, Baldwin and Okubo (2012) also utilize data on the sales and purchases of foreign affiliates to define "networked FDI."

evidence is found for Europe.

The analysis in this study has important policy implications. Our empirical findings suggest that Japanese MNEs make use of innovations in host countries differently, depending on the technological level of the host countries. In Asia, Japanese MNEs seem to utilize innovation by local firms in the host countries to strengthen regional production networks. In the US and Europe, in contrast, innovation by local firms seems to contribute to the enhancement of the vertical production networks of Japanese MNEs between these regions and Japan. Therefore, the progress in regional trade integration in Asia will increase the benefits of local innovation to Japanese MNEs. On the other hand, bilateral trade liberalization between the US and Japan may be effective. Moreover, signing an economic partnership agreement with the European Union may promote the development of both vertical and regional production networks by Japanese MNEs in the European region.

The rest of this paper is organized as follows. In section 2, we discuss the theoretical background of our empirical analysis. In section 3, we describe the data employed in our empirical study. We also explain the indexes that measure the different types of FDI. In section 4, we explain our empirical methodology. In section 5, we present and discuss our empirical results. In section 6, we provide concluding remarks.

2 Theoretical Background

To motivate the empirical analysis of the relationship between the innovative performance of local firms in the same and related industries in the host county and the structure of FDI, we briefly illustrate our theoretical background.

We extend the three-country FDI model in the literature (e.g., Yeaple, 2003, Ekholm et al., 2007) to a four-country model (see Figure 2). There are four countries: the source country (country S) of FDI, the host country (country H) of FDI, the third country (country T) in the same region as country H, and the rest of the world (country R). Country T may be absent in some cases. Although there are many industries, we focus only on one. A representative firm in country S, called firm P, locates its headquarters in country S and establishes a foreign affiliate, called firm A, in country H. In our analysis, as in Hanson et al. (2005), we assume that firm P has previously chosen the location of its foreign affiliate and that the remaining decision that it needs to make relates to which production activities its foreign affiliate should conduct.

As in Jinji et al. (2011), we assume that the production of differentiated final consumption goods requires three stages of production processes. The three stages of production may be located in one place or may be located in different places. Note that in this framework, the relationship between the parent firm P and its foreign affiliate A may be horizontal, vertical, or export-platform.

Consumers are located in all four countries. Moreover, there are local firms in countries H and

T (if T exists). These local firms may be firm A's competitors in the output (consumption goods) market or may be partners in selling or buying inputs (raw materials and intermediate goods). Local firms in country H also conduct innovative activities to improve their own production technologies.

The effects of innovation by local firms on the structure of FDI therefore depend on the motivation for FDI. Consider first the case in which firm A is involved in horizontal FDI. In this case, firm A's share of input purchases from local firms in country H, Sh_H^P, which is defined below, is high and its share of sales to local firms in country H or to consumers in country H, Sh_H^S, is also high. There is a *competition effect*, which negatively affects the share of horizontal sales if firm A sells outputs (final consumption goods) to local consumers (i.e., typical horizontal FDI) and local firms also sell outputs to local consumers. However, there is a *technology-improvement effect*, which positively affects the share of horizontal sales if firm A sells outputs (intermediate goods) and sources inputs from local firms (i.e., local production network). Because there are both positive and negative effects, the total effect depends on the conditions.

Consider next the case in which firm A is involved in vertical FDI. In this case, firm A's share of input purchases from country S, Sh_V^P, is high and its share of sales to country S, Sh_V^S, is also high. There are again two opposing effects in this case. The first is a *comparative-advantage-weakening effect*. If FDI is motivated by factor price differentials (i.e., the usual North-South vertical FDI), then because the technological improvement resulting from innovation tends to narrow the factor price differential, this effect is expected to weaken the motive for vertical FDI. In contrast, a *production-network-enhancing effect* tends to strengthen the motive for vertical FDI if FDI is attractive due to the high level of technology in the host country in some stages of production, which is typically the case in North-North vertical FDI (Jinji et al., 2011).

For foreign affiliate A, the third country (i.e., country T) in the same region may just be the destination of its outputs or may be part of its production networks. In the former case, sales to country T are simply a component of sales to the rest of the world (i.e., country R), and hence, it is appropriate to jointly consider the share of sales to country T and the share of sales to country R as Sh_X^S. In the latter case, in contrast, transactions with local firms in country T are included in the production processes. Thus, we should treat sales to and purchases from country T separately from the shares of sales to and purchases from country R as Sh_X^S and Sh_X^P, respectively.

In the subsequent sections, we empirically investigate the effects discussed above by utilizing firm-level data from the foreign affiliates of Japanese MNEs.

3 Data

In this section, we explain the data employed in our empirical analysis and the indexes used to measure the structure of FDI.

3.1 Data on the FDI and patent applications

First, we collect data on Japanese MNEs and their foreign affiliates from two surveys conducted by the Japanese Ministry of Economy, Trade and Industry (METI). These surveys are the Survey on Overseas Business Activities (*Kaigai Jigyo Katsudo Kihon Chosa*, KJKKC) and the Basic Survey of Japanese Business Structure and Activities (*Kigyo Katsudo Kihon Chosa*, KKKC).[2] The KJKKC is a survey of Japanese firms that, as of the end of March every year, own or have previously owned overseas affiliates. The foreign affiliates listed in the KJKKC are either foreign affiliates with at least 10% of their capital held by a Japanese parent company, or foreign affiliates with at least 50% of their capital held by a foreign subsidiary, which, in turn, has at least 50% of its capital held by a Japanese parent company.[3] The KJKKC includes detailed data on affiliate-level FDI activities, such as the sales and purchases of foreign affiliates, classified by their destinations and sources, that is, sales to (or purchases from) the local market in the host country or exports to (or imports from) Japan and a third country. Although the KJKKC started in 1971, electronic data are available only since 1995. METI reports that approximately 16,000 foreign affiliates responded to the KJKKC in 2006. In contrast, the KKKC is a survey for all firms with 50 or more employees and paid-up capital or investment funds exceeding 30 million yen. We extract data on Japanese parent companies from the KKKC and combine these data with data from the KJKKC.

Table 1 shows the top 20 host economies for Japanese MNEs in 2006, based on the number of affiliates that completed the KJKKC. As shown in the table, China attracted the largest number of Japanese MNEs' affiliates, followed by the US. Both Asian economies and developed countries are popular host economies for Japanese MNEs.

The patent application data are taken from the April 2012 edition of the EPO Worldwide Patent Statistical Database (PATSTAT). We extract the patent statistics of the USPTO from the PATSTAT. This dataset includes information on the application date, the country, the name of the assignee, and the main US patent class of each patent. In our analysis, we use patent application data from 1975 to 2006.

Because FDI data are available since 1995 and patent data are available until 2006, our sample period is from 1995 to 2006.

[2]See the METI websites for details on these surveys (KJKKC: `http://www.meti.go.jp/english/statistics/tyo/kaigaizi/index.html`; and KKKC: `http://www.meti.go.jp/english/statistics/tyo/kikatu/index.html`).

[3]The KJKKC excludes foreign affiliates in the financial, insurance, and real estate industries.

We also obtain the nominal GDPs and GDP deflators of the host countries from the World Bank's World Development Indicators and create real GDPs.[4]

3.2 The structure of FDI

In the literature, FDI and MNEs' activities are usually categorized into horizontal (Markusen, 1984), vertical (Helpman, 1984), and export-platform (Ekholm et al., 2007). Horizontal FDI is typically characterized by transactions in the local market, whereas vertical FDI involves transactions with the source country. Transactions with a third country represent an important factor for the third type of FDI.

An advantage of the KJKKC dataset is that it allows us to measure the structure of FDI by using information on the output sales and input purchases by foreign affiliates.

Let $Value^S_{TOT}(i,j,k,t)$ and $Value^P_{TOT}(i,j,t)$ be the total value of output sales and of input purchases, respectively, for affiliate i in host country j in sector k in year t, where the superscript S indicates "sales," the superscript P indicates "purchases," and the subscript TOT indicates the "total" value. Similarly, let $Value^l_{LOC}(i,j,k,t)$ be the value of transaction $l = S, P$ made in host country j, where the subscript LOC refers to "local" transaction, $Value^k_{JP}(i,j,k,t)$ is the value of transaction $l = S, P$ made to (or from) Japan, and $Value^k_{3RD}(i,j,k,t)$ is the value of transaction $l = S, P$ made to (or from) the third country. Then, the share of the transaction $l = S, P$ with $n = LOC, JP, 3RD$ in the total value of transaction $l = S, P$, denoted by $Sh^l_m(i,j,t)$, $m = H, V, X$, is defined as

$$Sh^l_H(i,j,k,t) = \frac{Value^l_{LOC}(i,j,k,t)}{Value^l_{TOT}(i,j,k,t)}, \tag{1}$$

$$Sh^l_V(i,j,k,t) = \frac{Value^l_{JP}(i,j,k,t)}{Value^l_{TOT}(i,j,k,t)}, \tag{2}$$

$$Sh^l_X(i,j,k,t) = \frac{Value^l_{3RD}(i,j,k,t)}{Value^l_{TOT}(i,j,k,t)}, \tag{3}$$

where the subscripts H, V, and X indicate that the type of FDI is horizontal, vertical, and export-platform, respectively. Because procurement from the third country is a mirror image of sales to the third country, we also indicate it as type X.

Table 2 shows the average values of those shares during the sample period (i.e., 1995–2006). The table also indicates the averages in the periods of 1995–1999 and 2000–2006. The table shows the shares in the entire sample (indicated as "World") and the three subsamples, namely, for the affiliates located in the US, European countries, and Asian countries.

As shown in the table, the share of sales to the local market is about 0.61. This share is much higher in the US (about 0.86) and slightly lower in Asian countries (about 0.55). Further, the share of purchases from the local market is about 0.51. This share is slightly higher in the US (about 0.58)

[4] Taiwan's GDP and GDP deflator are taken from the National Statistics of Taiwan.

and much lower in European countries (about 0.40). Interestingly, the share of purchases from Japan is about 0.35, regardless of the region. Moreover, the share of each type is relatively constant over time.

3.3 Data matching

We need to match the FDI data with the patent data. The patent statistics are classified by the IPC, which is based either on the intrinsic nature of the invention or on its function. Schmoch *et al.* (2003) provide a concordance table between technical fields and industrial sectors. This concordance table refers to IPC for patents, and international classifications, namely the European Union's Classification of Economic Activities within the European Communities (NACE), the United Nations' International Standard Industrial Classification (ISIC), and the US Standard Industrial Classification (SIC) with 44 industrial fields. We use their concordance table to allocate the patent statistics into 44 industrial fields. Because the foreign affiliates of Japanese MNEs are asymmetrically distributed across the 44 fields, we further aggregate 44 fields into 13 sectors (See Table A.1).

We also categorize the industrial classification of the KJKKC into 13 sectors to match the KJKKC's FDI data with the USPTO patent data.

4 Empirical Methodology

The main issue examined in this study is how the innovative performance of local firms in host countries affects the selection among the horizontal, vertical, and export-platform structures of FDI by Japanese MNEs. To investigate this issue, we employ the following strategy.

First, we measure the innovative performance of local firms in the same and related industries in a host country by the number of patent applications in sector k in host country j per country j's real GDP, denoted by $(P_{jkt}/RGDP_{jt})$. As is well known from the FDI theory, a larger market in the host country tends to encourage horizontal FDI (Markusen, 2002). To control for this motivation, we divide the number of patent applications by the host country's real GDP.

We then employ the following specification for our estimation:

$$Sh_m^l(i,j,k,t) = \alpha + \beta_1 Ln(P/RGDP)_{jkt} + \beta_2 LnDist_j + \beta_3 LnKL_{it} + \beta_4 D_{RD,it} + \varepsilon_{ijkt}, \quad (4)$$

where $Ln(P/RGDP)_{jkt} = \ln(P_{jkt}/RGDP_{jt})$, $LnDist_j$ is the logarithm of the distance between Japan and the host country j, $LnKL$ is the logarithm of the capital–labor ratio of affiliate i, $D_{RD,it}$ is a dummy variable, which equals unity if affiliate i conducts research and development (R&D) and zero otherwise, and ε_{ijkt} is an error term.[5] The first two variables ($Ln(P/RGDP)$ and $LnDist$) capture

[5] Although the METI survey is conducted every year, there are many missing values in the data for a particular firm

the characteristics of the host country j and the next two variables ($LnKL$ and D_{RD}) capture the characteristics of affiliate i.

Note that $LnDist_j$ is a proxy for transport costs between the source country (Japan) and the host country. Higher transport costs discourage vertical FDI in both sales and purchases. In contrast, higher transport costs encourage horizontal FDI in both sales and purchases because they make exports from the source country more expensive. Thus, we include $LnDist_j$ to control for these motivations.

Because the dependent variable $Sh^l_m(i,j,k,t)$ in Eq. (4) takes a value between 0 and 1 and a relatively large number of observations take either 0 or 1, we employ the two-limit tobit model. Now $Sh^l_m(i,j,k,t)$ is a latent variable and we set the lower and upper limits of the censored distribution at 0 and 1, respectively. Thus,

$$Sh^{l*}_m(i,j,k,t) = \begin{cases} 0 & \text{if } Sh^l_m(i,j,k,t) \leq 0, \\ Sh^l_m(i,j,k,t) & \text{if } Sh^l_m(i,j,k,t) \in (0,1), \\ 1 & \text{if } Sh^l_m(i,j,k,t) \geq 1. \end{cases} \quad (5)$$

We then estimate Eq. (5) using the maximum-likelihood.

To capture regional heterogeneity in the effects of the innovative performance of local firms in the host country, we estimate the marginal effects of the interaction terms between $Ln(P/RGDP)$ and regional dummies for the US, European countries, and Asian countries. We adopt the estimation procedure suggested in the literature (Ai and Norton, 2003; Karaca-Mandic, 2012) to estimate the marginal effects of the interaction terms in nonlinear models.[6]

5 Results

5.1 Basic estimations

The estimated results of Eq. (5) are reported in Table 3. First, we find that $Ln(P/RGDP)$ has a significantly positive effect on the horizontal type of FDI in purchases (column (2)) but an insignificant effect on the horizontal type of FDI in sales (column (1)). In contrast, it has a significantly positive effect on the vertical type of FDI in sales (column (3)) and a significantly negative effect on the share of transaction with a third country in purchases (column (6)).

Second, the estimated marginal effects of the interactions between $Ln(P/RGDP)$ and the regional dummies indicate considerable regional heterogeneity. The marginal effect of the interaction between $Ln(P/RGDP)$ and the regional dummy on the share of the local market is significantly positive for both local sales and purchases in Europe and Asia, whereas it is significantly negative for both

because in some years certain respondents did not report to METI. For this reason, we only use pooled data in our estimation. In the estimations, we include year and sector dummies.

[6] We use Stata's command `margins` to estimate the marginal effects of the interaction terms.

local sales and purchases in the US (columns (1) and (2)). Thus, in Europe and Asia, the innovative performance of local firms of the same and related sectors in the host country strengthens both forward and backward linkages in the host country. However, no such effect is observed in the US. This may because horizontal FDI to the US is mainly motivated by supplying to the US market rather than utilizing forward and backward linkages in the US local market. Moreover, the estimated marginal effect on the share of vertical transactions with the source country in sales and purchases is significantly positive for the US and Europe, whereas it is significantly negative for Asia (columns (3) and (4)). This implies that innovation by local firms encourages vertical FDI, particularly in technologically advanced host countries. This may occur because the motivation for vertical FDI to technologically advanced countries is different from the usual motivations (Jinji et al., 2011). Usually, vertical FDI is motivated by labor cost savings through FDI to low-wage countries. In contrast, North-North vertical FDI may be motivated by the exploitation of technological advantages in production process. Finally, the marginal effect on the share of export-platform FDI is significantly positive for the US and Asia, but it is significantly negative for Europe (column (5)). However, since Sh_X^S includes exports to countries in the same region, the estimated effect may not properly capture the case of export-platform FDI in Europe and Asia. Thus, we investigate further this issue below.

5.2 Alternative estimations

To check the robustness of the results in the previous subsection, we conduct a number of alternative estimations. First, we add two variables for Japanese parent companies to the explanatory variables in Eq. (4). These variables are $LnLP_{hq,it}$ and $Ln(RD/S)_{hq,it}$. The former is the logarithm of the labor productivity of the parent firm of affiliate i, which is calculated by the value-added divided by the number of regular employees. This variable captures the productivity of the parent firm. The latter is the R&D intensity of the parent firm of affiliate i, which is the logarithm of the annual R&D expenditure of the parent firm divided by its total sales. The results are reported in Table 4. Since some Japanese parent companies of the foreign affiliates that responded to the KJKKC survey did not respond to the KKKC survey in the same year, the number of observations in Table 4 is reduced from that in Table 3. Our primary interest is in the estimated coefficient of $Ln(P/RGDP)$ and the marginal effects of the interactions between $Ln(P/RGDP)$ and regional dummies. For the most part, the results in Table 4 are qualitatively the same as those in Table 3. The only changes from Table 3 are that the marginal effect on Sh_H^S for Europe becomes insignificant (column (1)) and the significance level of that on Sh_V^P for Europe is reduced (column (4)).

Second, since simultaneity bias and reverse causality are suspected when we estimate Eq. (4), we take one lag period for $Ln(P/RGDP)$, $LnKL$, and D_{RD}. Table 5 reports the estimated results with lagged variables. Since the same respondent may not have answered the KJKKC survey in two successive years, the number of observations in Table 5 is reduced from that in Table 3. We observe that in some cases, the significance level of the estimated coefficient in Table 5 is reduced from that in Table 3; however, for the most part, the qualitative results do not change from those in Table 3.

Third, the changes in *share* of each type of transaction may not properly capture the impact of the innovative performance of the local firms on FDI. To investigate this issue, we estimate the effects of $Ln(P/RGDP)$ on the logarithm of the values of various transaction types. In this case, our dependent variable is the logarithm of the value of the transaction $l = S, P$ of type $m = H, V, X$ for an affiliate i in host country j in sector k in year t:

$$Ln(Val^l_m(i,j,k,t)) \equiv \log\left(Value^l_n(i,j,k,t)\right), \qquad n = \{LOC, JP, 3RD\}. \tag{6}$$

We then estimate Eq. (4) by replacing the left-hand side with $Ln(Val^l_m(i,j,k,t))$ in Eq. (6) and by using the ordinary least squares (OLS). We include interaction terms between $Ln(P/RGDP)$ and three regional dummies (US, $Euro$, and $Asia$). The estimated results are reported in Table 6. Compared to the results in Table 3, we observe several changes in Table 6. First, the effect of $Ln(P/RGDP)$ on horizontal FDI in sourcing (column (2)) now becomes insignificant (with an opposite sign). Second, although the signs of the interaction terms between $Ln(P/RGDP)$ and the regional dummies in Table 6 are the same as those of the marginal effects in Table 3, the level of statistical significance decreases in several instances. For example, the coefficient of the interaction term is insignificant for the US and Asian countries in column (1), and it is also insignificant for the European countries in columns (2) and (3). Thus, some of the effects of innovative performance of the local firms in the host country on FDI that were discussed in the previous subsection may be weaker when we focus on the size of each transaction type. However, since large changes from the results in Table 3 are not observed in Table 6, we conclude that our approach to measuring the effects in question in the previous subsection is appropriate.

5.3 Regional perspective

To further investigate the region-wide activities of the foreign affiliates of Japanese MNEs, we define two additional share indexes. Let $Value^l_{REG}(i,j,k,t)$ be the value of transaction $l = S, P$ conducted within the region (but outside country j) where host country j is located and $Value^l_{OUT}(i,j,k,t)$ be the value of transaction $l = S, P$ conducted outside the region where host country j is located (and excluding Japan). Then, we can define the share of transaction $l = S, P$ of the "regionally horizontal" type, $Sh^l_{RH}(i,j,k,t)$, by

$$Sh^l_{RH}(i,j,k,t) = \frac{Value^l_{LOC}(i,j,k,t) + Value^l_{REG}(i,j,k,t)}{Value^l_{TOT}(i,j,k,t)}. \tag{7}$$

We can also define the share of transaction $l = S, P$ of the "outside of region" type, $Sh^l_{RX}(i,j,k,t)$, by

$$Sh^l_{RX}(i,j,k,t) = \frac{Value^l_{OUT}(i,j,k,t)}{Value^l_{TOT}(i,j,k,t)}. \tag{8}$$

Table 7 shows the average values of Sh^l_{RH} and Sh^l_{RX}, $l = S, P$, in Asia and Europe. In Europe, the share of sales to markets within the region is about 0.90, which is almost the same as the share of sales to the local market in the US (see Table 2). In contrast, in Asia, the share of the local market in sales of foreign affiliates is about 0.70 even when we extend the range of the "local market" to the entire region. The reason for this is that the share of exports to Japan is much higher (about 0.28) in affiliates located in Asian countries, compared to those located in the US and Europe (about 0.06 and 0.05, respectively). As for sales to outside the region, the share is almost the same in Europe and Asia (about 0.06 and 0.07, respectively). With regard to the sourcing of inputs, the share of the markets within the region is about 0.56 in Europe and 0.62 in Asia. The figure in Europe is comparable to that in the US, and the share in Asia is higher than in other regions.

Moreover, we also define the logarithm of the values of regionally horizontal type of transactions and outside of region type transactions by

$$Ln(Val^l_{RH}(i,j,k,t)) \equiv \log\left(Value^l_{LOC}(i,j,k,t) + Value^l_{REG}(i,j,k,t)\right), \tag{9}$$

$$Ln(Val^l_{RX}(i,j,k,t)) \equiv \log\left(Value^l_{OUT}(i,j,k,t)\right), \tag{10}$$

where $l = S, P$.

We then estimate Eq. (4) with Sh^l_{RH} and Sh^l_{RX}, defined in Eqs. (7) and (8), respectively, by tobit and Eq. (4) with $Ln(Val^l_{RH})$ and $Ln(Val^l_{RX})$, defined in Eqs. (9) and (10), respectively, by OLS. We focus on Asia and Europe. The results are reported in Table 8. The estimated tobit results are reported in columns (1)–(4) and the OLS results are reported in columns (5)–(8). As indicated in the table, in Asia, $Ln(P/RGDP)$ has a significantly positive effect on the share of transactions within the region in terms of both sales and purchases. In contrast, in Europe, the effect of $Ln(P/RGDP)$ on the share of transactions within the region is significantly negative for sales and insignificant for purchases. These results suggest that in Asia, innovation by local firms of the same and related sectors strengthens regional production ties. This finding supports the concept of fragmentation within the Asian region (Kimura and Ando, 2003, 2005). In Europe, in contrast, we do not find evidence of such an effect. The OLS estimations reported in columns (5)–(8) confirm that the findings in the cases of shares are largely robust.

6 Conclusions

In this study, we examined the effects of the innovative performance of local firms in the host country on the structure of FDI measured by the patterns of sales and purchases by foreign affiliates. We used firm-level data from foreign affiliates of Japanese MNEs and patent application data from their host countries obtained from the USPTO. Our estimation results indicated that innovation in the host country strengthens forward and backward linkages in the host country in Asian and European countries, whereas this is not the case for affiliates located in the US. Moreover, we also found that innovation in technologically advanced host countries enhances vertical production networks (i.e., North-North vertical FDI). Finally, our finding suggests that in Asian countries, the innovative performance of local firms contributes to the development of regional production networks.

Our future research will analyze the feedback effects of innovation in the host country to Japanese parent firms and the Japanese economy in terms of the innovative performance and productivity of Japanese firms. Another issue is the interaction between the effect of local innovation on the FDI structure and the trade patterns that reflect the comparative advantages of the host country.

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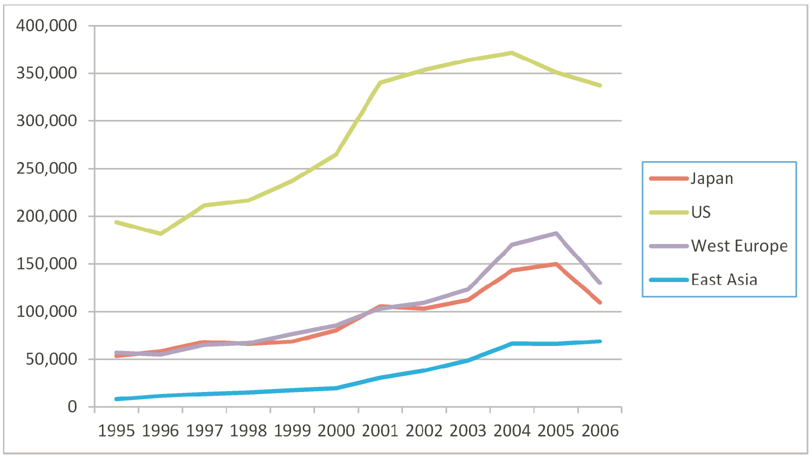

Figure 1: The Number of Patent Applications at the USPTO

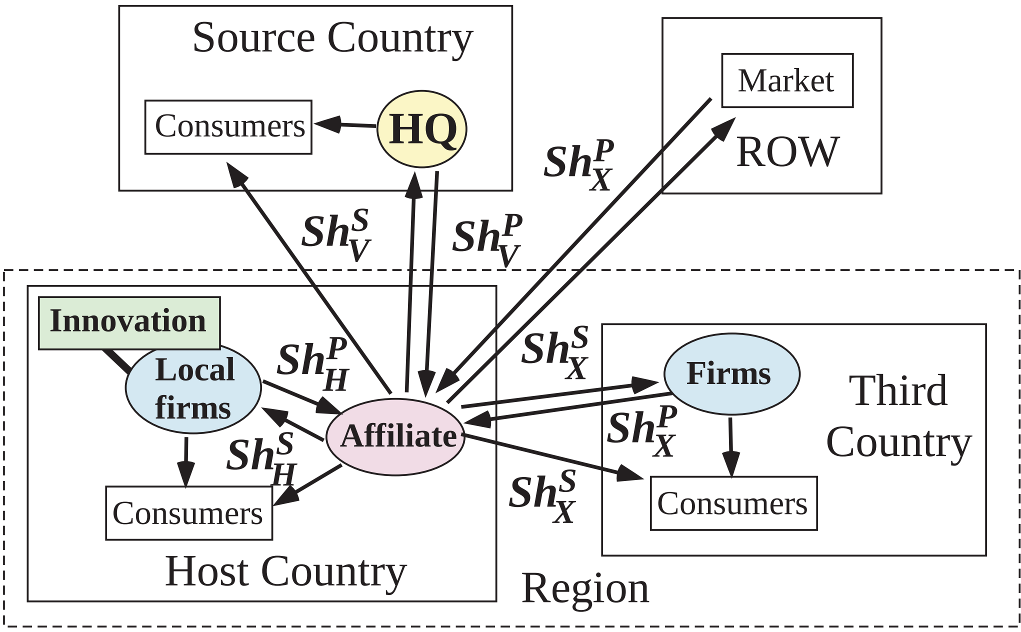

Figure 2: Analytical Framework: Four-country Model

Table 1: Top 20 FDI Host Countries/Economies in Year 2006

Country/Economy	No. of affiliates	Country/Economy	No. of affiliates
China	1666	United Kingdom	127
United States	730	Vietnam	117
Thailand	516	Germany	96
India	294	Brazil	63
Malaysia	272	Indonesia	61
Taiwan	266	France	60
Hong Kong	222	Canada	58
Korea	191	Netherlands	48
Singapore	187	Australia	47
Philippines	158	Mexico	44

Note: The number of affiliates is counted in our sample in 2006.

Table 2: Average Shares of the Three FDI Types in Sales and Purchases of Foreign Affiliates

		Sales			Purchases		
		Sh_H^S	Sh_V^S	Sh_X^S	Sh_H^P	Sh_V^P	Sh_X^P
World	Whole period	0.614	0.212	0.207	0.512	0.356	0.167
	1995–1999	0.624	0.200	0.224	0.491	0.375	0.186
	2000–2006	0.610	0.218	0.199	0.522	0.348	0.159
US	All period	0.862	0.062	0.093	0.576	0.357	0.089
	1995–1999	0.854	0.065	0.105	0.585	0.356	0.085
	2000–2006	0.866	0.060	0.087	0.571	0.357	0.091
Europe	Whole period	0.614	0.053	0.357	0.404	0.367	0.265
	1995–1999	0.646	0.041	0.337	0.413	0.359	0.271
	2000–2006	0.596	0.060	0.369	0.398	0.371	0.262
Asia	Whole period	0.549	0.281	0.206	0.513	0.362	0.160
	1995–1999	0.544	0.278	0.235	0.477	0.393	0.187
	2000–2006	0.551	0.282	0.195	0.528	0.349	0.151

Source: The authors' calculation from the KJKKC data.

Table 3: The Effects of Innovation in the Host Country on the Structure of FDI

	(1) Sh_H^S	(2) Sh_H^P	(3) Sh_V^S	(4) Sh_V^P	(5) Sh_X^S	(6) Sh_X^P
$Ln(P/RGDP)$	0.0031	0.0047**	0.0078***	−0.0013	−0.0027	−0.0033*
	(1.48)	(2.48)	(3.25)	(−0.71)	(−1.51)	(−1.74)
$LnDist$	−0.080***	−0.030***	−0.072***	−0.046***	0.187***	0.133***
	(−10.23)	(−4.30)	(−9.93)	(−7.03)	(24.55)	(16.55)
$LnKL$	0.021***	−0.015***	−0.018***	0.013***	−0.0065***	−0.00059
	(11.73)	(−9.45)	(−10.96)	(8.93)	(−4.00)	(−0.34)
D_{RD}	−0.023***	0.045***	0.029***	−0.029***	0.074***	0.051**
	(−4.41)	(9.49)	(5.87)	(−6.58)	(15.10)	(9.81)
Marginal effects						
$Ln(P/RGDP) \times US$	−0.023***	−0.028***	0.022***	0.047***	0.025***	−0.014**
	(−3.92)	(−5.38)	(4.05)	(9.45)	(4.65)	(−2.43)
$Ln(P/RGDP) \times Euro$	0.012***	0.0050*	0.011***	0.014***	−0.012***	−0.020***
	(4.20)	(1.91)	(3.42)	(5.66)	(−5.04)	(−7.87)
$Ln(P/RGDP) \times Asia$	0.0015**	0.0070***	−0.0046***	−0.0039***	0.0040***	−0.0051***
	(2.36)	(12.01)	(−7.60)	(−7.23)	(6.59)	(−8.21)
No. of obs.	34256	34256	34256	34256	28416	26414
Pseudo R^2	0.1067	0.0740	0.1362	0.0714	0.1073	0.0957

Notes: (a) "***," "**", and "*" denote 1%, 5%, and 10% significance levels, respectively.

(b) The values in the parentheses are t-statistics.

(c) Constant term and year, region, and sector dummies are included in the estimations.

(d) Marginal effects of the interaction terms are computed using Stata's command `margins`.

Table 4: The Effects of Innovation in the Host Country with Parent Firm's Variables

	(1)	(2)	(3)	(4)	(5)	(6)
	Sh_H^S	Sh_H^P	Sh_V^S	Sh_V^P	Sh_X^S	Sh_X^P
$Ln(P/RGDP)$	−0.0012	0.0097***	0.017***	−0.0012	−0.0025	−0.0087***
	(−0.41)	(3.84)	(4.71)	(−0.52)	(−1.05)	(−3.63)
$LnDist$	−0.074***	−0.027***	−0.065***	−0.024**	0.177***	0.085***
	(−6.56)	(−2.60)	(−6.08)	(−2.50)	(16.11)	(7.51)
$LnKL$	0.013***	−0.013***	−0.015***	0.015***	−0.00041	−0.0049**
	(5.07)	(−5.59)	(−6.21)	(6.93)	(−0.17)	(−2.00)
D_{RD}	−0.025***	0.041***	0.035***	−0.017***	0.074***	0.040***
	(−3.37)	(6.17)	(5.01)	(−2.71)	(10.73)	(5.55)
$LnLP_{hq}$	0.016**	0.016**	−0.0016	0.00013	−0.0067	−0.018**
	(2.27)	(2.41)	(−0.23)	(0.02)	(−0.99)	(−2.43)
$Ln(RD/S)_{hq}$	−0.0020***	0.00050	0.0025***	0.00084*	−0.00064	−0.0026***
	(−3.76)	(1.04)	(4.95)	(1.87)	(−1.26)	(−4.70)
Marginal effects						
$Ln(P/RGDP) \times US$	−0.028***	−0.023***	0.031***	0.045***	0.030***	−0.020**
	(−3.40)	(−3.06)	(3.84)	(6.45)	(3.74)	(−2.37)
$Ln(P/RGDP) \times Euro$	0.0040	0.012***	0.015***	0.0067*	−0.010***	−0.020***
	(0.91)	(3.17)	(3.01)	(1.82)	(−2.71)	(−5.50)
$Ln(P/RGDP) \times Asia$	0.0015*	0.0069***	−0.0045***	−0.0040***	0.0043***	−0.0048***
	(1.69)	(8.48)	(−5.36)	(−5.27)	(4.98)	(−5.50)
No. of obs.	17207	17207	17207	17207	14002	12999
Pseudo R^2	0.1087	0.0709	0.1375	0.0708	0.1139	0.1091

Notes: (a) "***," "**", and "*" denote 1%, 5%, and 10% significance levels, respectively.

(b) The values in the parentheses are t-statistics.

(c) Constant term and year, region, and sector dummies are included in the estimations.

(d) Marginal effects of the interaction terms are computed using Stata's command `margins`.

Table 5: The Effects of Innovation in the Host Country with Lagged Variables

	(1) Sh_H^S	(2) Sh_H^P	(3) Sh_V^S	(4) Sh_V^P	(5) Sh_X^S	(6) Sh_X^P
$Ln(P/RGDP)_{t-1}$	0.0035	0.0018	0.0063**	−0.00032	−0.00327	−0.0017
	(1.29)	(0.74)	(2.06)	(−0.14)	(−1.31)	(−0.72)
$LnDist$	−0.071***	−0.032***	−0.079***	−0.050***	0.174***	0.125***
	(−7.88)	(−3.90)	(−9.55)	(−6.58)	(19.80)	(13.91)
$LnKL_{t-1}$	0.016***	−0.015***	−0.015***	0.015***	−0.0051***	−0.00092
	(7.62)	(−7.92)	(−7.39)	(8.22)	(−2.58)	(−0.46)
$D_{RD,t-1}$	−0.016***	0.043***	0.013***	−0.032***	0.057***	0.028***
	(−2.62)	(7.89)	(2.29)	(−6.27)	(9.95)	(4.75)
Marginal effects						
$Ln(P/RGDP)_{t-1} \times US$	−0.012*	−0.034***	0.0089	0.043***	0.023***	−0.0058
	(−1.72)	(−5.74)	(1.42)	(8.00)	(3.45)	(−0.89)
$Ln(P/RGDP)_{t-1} \times Euro$	0.014***	0.0049*	0.0056*	0.011***	−0.016***	−0.015***
	(4.66)	(1.69)	(1.73)	(4.01)	(−5.66)	(−5.58)
$Ln(P/RGDP)_{t-1} \times Asia$	0.0018***	0.0057***	−0.0053***	−0.0032***	0.0038***	−0.0047***
	(2.33)	(8.32)	(−7.68)	(−5.09)	(5.30)	(−6.47)
No. of obs.	20075	20075	20075	20075	16851	15681
Pseudo R^2	0.1311	0.0878	0.1636	0.0892	0.1209	0.1040

Notes: (a) "***," "**", and "*" denote 1%, 5%, and 10% significance levels, respectively.

(b) The values in the parentheses are t-statistics.

(c) Constant term and year, region, and sector dummies are included in the estimations.

(d) Marginal effects of the interaction terms are computed using Stata's command `margins`.

Table 6: Alternative Estimation: Log of Values by OLS

	(1) $Ln(Val^S_H)$	(2) $Ln(Val^P_H)$	(3) $Ln(Val^S_V)$	(4) $Ln(Val^P_V)$	(5) $Ln(Val^S_X)$	(6) $Ln(Val^P_X)$
$Ln(P/RGDP)$	0.067	−0.025	0.256***	0.039	−0.079	−0.027
	(1.58)	(−0.59)	(4.89)	(0.67)	(1.27)	(−0.42)
$Ln(P/RGDP) \times US$	−0.121	−0.465***	0.776***	0.440***	1.359***	−0.170
	(−1.47)	(−4.00)	(4.59)	(2.85)	(7.41)	(−0.85)
$Ln(P/RGDP) \times Euro$	0.233***	0.126	0.135	0.244***	−0.022	−0.292***
	(2.78)	(1.61)	(1.44)	(2.65)	(−0.23)	(−2.90)
$Ln(P/RGDP) \times Asia$	0.017	0.082*	−0.245***	−0.051	0.175***	−0.086
	(0.39)	(1.88)	(−4.52)	(−0.87)	(2.72)	(−1.32)
$LnDist$	0.095	0.375***	−0.682***	0.212	5.041***	4.327***
	(0.84)	(2.73)	(−3.14)	(1.33)	(20.30)	(16.95)
$LnKL$	0.209***	−0.274***	−0.376***	0.041	−0.268***	−0.173***
	(6.17)	(−7.74)	(−7.53)	(0.92)	(−5.06)	(−3.06)
D_{RD}	1.692***	2.287***	3.78***	2.14***	4.451***	3.99***
	(20.49)	(25.22)	(26.92)	(19.18)	(28.69)	(24.25)
No. of obs.	34256	34256	34256	34256	28416	26416
R^2	0.0817	0.0528	0.1167	0.1082	0.1363	0.1508

Notes: (a) "***," "**", and "*" denote 1%, 5%, and 10% significance levels, respectively.

(b) The values in the parentheses are robust t-statistics.

(c) Constant term and year, region, and sector dummies are included in the estimations.

Table 7: Average Shares of Regionally Horizontal and Outside of Region FDI

		Sales		Purchases	
		Sh^S_{RH}	Sh^S_{RX}	Sh^P_{RH}	Sh^P_{RX}
Europe	Whole period	0.885	0.063	0.559	0.083
	1995–1999	0.900	0.053	0.563	0.081
	2000–2006	0.877	0.068	0.558	0.084
Asia	Whole period	0.685	0.067	0.620	0.029
	1995–1999	0.690	0.079	0.579	0.038
	2000–2006	0.683	0.063	0.634	0.026

Source: The authors' calculation from the KJKKC data.

Table 8: Regionally Horizontal FDI in Asia and Europe

	Tobit				OLS			
	Sh^S_{RH}	Sh^P_{RH}	Sh^S_{RX}	Sh^P_{RX}	$Ln(Val^S_{RH})$	$Ln(Val^P_{RH})$	$Ln(Val^S_{RX})$	$Ln(Val^P_{RX})$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Asia								
$Ln(P/RGDP)$	0.0030***	0.0021***	0.0026***	0.0018***	0.066***	0.0098	0.158***	0.102***
	(3.85)	(3.18)	(3.96)	(2.70)	(5.50)	(0.86)	(6.93)	(4.98)
$LnDist$	0.026***	0.059***	0.084***	0.061***	0.806***	0.956***	3.392***	2.053***
	(2.67)	(6.71)	(10.42)	(7.10)	(8.14)	(6.16)	(11.11)	(7.33)
$LnKL$	0.038***	−0.019***	−0.012***	0.0033	0.209***	−0.286***	−0.376***	0.062
	(14.62)	(−8.22)	(−5.84)	(1.51)	(5.56)	(−7.60)	(−4.79)	(0.88)
D_{RD}	−0.012*	0.026***	0.091***	0.049***	1.368***	1.471***	4.314***	2.510***
	(−1.68)	(3.92)	(15.08)	(7.68)	(14.58)	(14.94)	(18.91)	(12.08)
No. of obs.	15878	14639	15714	14445	15889	14647	15714	14445
Pseudo R^2	0.0845	0.0496	0.0763	0.0723				
R^2					0.0887	0.0534	0.0764	0.0509
Europe								
$Ln(P/RGDP)$	−0.058**	−0.0044	0.0111***	−0.0049*	0.034	−0.042	0.547***	−0.103
	(−2.01)	(−1.22)	(3.90)	(−1.84)	(1.60)	(−1.20)	(7.05)	(−0.89)
$LnDist$	0.186*	0.057	−0.011	0.192*	1.903	4.433*	3.486	7.604
	(1.73)	(0.37)	(−0.13)	(1.68)	(1.28)	(1.84)	(0.81)	(1.54)
$LnKL$	−0.0030	−0.028***	−0.0067**	0.003	−0.109**	−0.439***	−0.382**	−0.105
	(−0.76)	(−4.58)	(−2.25)	(0.68)	(−2.41)	(−3.69)	(−2.26)	(−0.55)
D_{RD}	−0.099***	0.086***	0.088***	0.022*	0.508***	2.093***	6.102***	3.052***
	(−8.27)	(4.85)	(9.54)	(1.71)	(3.84)	(6.62)	(11.76)	(5.45)
No. of obs.	2875	2446	2859	2424	2877	2447	2859	2425
Pseudo R^2	0.0853	0.0810	0.1998	0.1334				
R^2					0.0427	0.0722	0.1156	0.1549

Notes: (1) "***," "**", and "*" denote 1%, 5%, and 10% significance levels, respectively.

(2) The values in the parentheses are t-statistics in tobit estimations and robust t-statistics in OLS estimations.

(3) Constant term and year and sector dummies are included in the estimations.

Table A.1: Correspondence among sectors, technical fields, and ISIC industrial classifications

Sector No.	Field No.	Field	ISIC ver. 3
1	1	food	15
1	2	tobacco	16
2	3	textiles	17
2	4	wearing	18
2	5	leather	19
2	6	wood products	20
2	7	paper	21
-	8	publishing	22
3	9	petroleum	23
3	10	basic chemicals	241
3	11	pesticides	2421
3	12	paint	2422
3	13	pharmaceuticals	2423
3	14	soaps	2424
3	15	other chemicals	2429
3	16	man-made fibers	243
4	17	plastic products	25
4	18	mineral products	26
13	19	basic metals	27
5	20	metal products	28
6	21	energy machinery	2911, 2912, 2913
6	22	non-specific machinery	2914, 2915, 2919
6	23	agricultural machinery	2921
6	24	machine-tools	2922
6	25	special machinery	2923, 2924, 2925, 2926, 2929
-	26	weapons	2927
7	27	domestic appliances	293
8	28	computers	30
7	29	electrical motors	311
7	30	electrical distribution	312, 313
7	31	accumulators	314
7	32	lightening	314
7	33	other electrical	315
8	34	electronic components	321
8	35	telecommunications	322
8	36	television	323
8	37	medical equipment	3311
8	38	measuring instruments	3312
8	39	industrial control	3313
9	40	optics	332
9	41	watches	333
10	42	motor vehicles	34
11	43	other transport	35
12	44	consumer goods	36

Notes: (a) Specification of fields is based on Tables 3–1 and 3–5 in Schmoch *et al.* (2003). (b) Field No. 8 "publishing" is excluded from our analysis because the USPTO does not have a corresponding field.