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Abstract

This paper aims to examine the relationship between the location choices of MNEs and their productivity considering the North-South differences in regard to technological constraints. We find that home firms with highest productivity levels choose to undertake FDI in the developed countries and those with highest productivity levels choose to export to, rather than do FDI in, developing countries. Using Japanese firm-level data, we also confirm that Japanese high-tech (high-productivity or R&D-intensive) firms tend to undertake FDI in developed countries, but hesitate to invest in developing countries empirically. This result explains why not many high-tech industries exist in developing countries.

1. Introduction

In recent decades, the influence of the behavior of multinational enterprises (MNEs) on the world economy has rapidly become stronger. Several empirical studies have been carried out on the location choice of MNEs and the factors that cause firms to cross national borders, but most of them have not focused on the differences between the conditions of individual firms. Thanks to the breakthrough model presented by Melitz (2003), analysts can examine foreign direct investment (FDI) in the context of heterogeneous firms (e.g., Helpman et al., 2004; Nocke and Yeaple, 2007, 2008; Nishiyama and Yamaguchi, 2010). Helpman et al. (2004) suggest that firms with the highest level of productivity choose to undertake FDI and firms with the second highest level of productivity choose to export. On the basis of data on Japanese firms for the year 1998, Tomiura (2007) demonstrates that FDI firms are distinctively more productive than foreign outsourcers, exporters and domestic firms. Further, some papers have examined the relationship between the location choices of firms and their productivity, taking North-South differences into consideration. For example, using a North-South model, Nishiyama and Yamaguchi (2010) suggest that firms with the first (highest) and second levels of productivity choose FDI. Using a North-South three-country model, Grossman et al. (2006) show that low-productivity firms do not undertake FDI and most productive firms move both intermediate and assembly stages into developing countries (South). They also suggest that the investment strategy of MNEs varies according to cost levels and market size. Aw and Lee (2008) develop a modified framework of Grossman et al.'s model to explain MNEs' integration strategies and show that firms with the highest level of productivity undertake FDI in both developed (North) and developing (South) countries. Firms with the second level of productivity do FDI in the North, and those with the third level of productivity do it in the South. Aw and Lee confirm that the results of the above theoretical predictions are supported by empirical analysis of the Taiwanese computer and telecommunications equipment industry.

Many previous works conclude that firms with high productivity tend to undertake FDI.[1] However, using a data set of Swedish MNEs from 1965 to 1994, Norbäck (2001) suggests that

[1] Yeaple (2009) and Chen and Moore (2009) consider the effects of the country's own characteristics on the location choices of firms. Yeaple analyzes the structure of U.S. multinational activity. Chen and Moore examine location decisions of French firms.

high-tech (or R&D-intensive) firms tend to choose exports rather than FDI to enter developed country markets.[2] On the other hand, it would seem that Japanese firms with high productivity tend to choose FDI in the developed but not developing countries (see section 3). How should we interpret these phenomena?

The key factor, which we consider in our analysis but other studies do not, is the existence of technological constraints. Firms producing high-tech outputs probably hesitate to undertake FDI in developing countries with low production technology, because their overseas subsidiaries face technological constraints in production. In fact, we observe that most centers of high-tech industries (Silicon Valley in the United States, Oulu in Finland, North East England in the United Kingdom, etc.) are located in developed countries. However, unfortunately, few studies examining the relationship between the location choices of MNEs and their productivity consider the differences in technological constraints between the North and the South.

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[2] Norbäck (2001) does not examine the advancement of Swedish MNEs to developing countries.

This paper aims to examine the relationship between the location choices of MNEs and their productivity considering the North-South differences in regard to technological constraints. In section 2, we present a heterogeneous firm model with technological constraints factored in and obtain the following two theoretical findings: First, home firms with highest productivity levels choose to undertake FDI in the developed countries. Second, contrary to Helpman et al.'s (2004) prediction, home firms with highest productivity levels choose to export to, rather than do FDI in, developing countries. The empirical counterpart to the theoretical model is presented in section 3. Using Japanese firm-level data, we confirm that Japanese high-tech (high-productivity or R&D-intensive) firms tend to undertake FDI in developed countries, but hesitate to invest in developing countries. This result explains why not many high-tech industries exist in developing countries. Section 4 presents our conclusions.

2. The model

2.1 Theoretical framework

Using a two-country model, we examine the behavior of home firms serving the domestic and foreign markets. In the home country, a continuum of monopolistic competition firms produce differentiated goods using labor. When a firm enters the market, it draws an initial productivity parameter ϕ, and estimates the expected profits under three production patterns: the "domestic firm," the "export firm," and the "FDI firm." The domestic firm has only a "domestic sector" that produces q_D for the home market. The export firm consists of a domestic sector and an "export sector" that produces q_{EX} for the foreign market. The FDI firm consists of a domestic sector and an "FDI sector" located in a foreign country, which produces q_{FD} for the foreign market; we may regard the FDI sector as a foreign subsidiary. Each firm compares the expected profits under the three different production patterns and determines the optimum pattern. Note that prior to market entry, differentiated goods firms are identical. We normalize the number of firms to 1. Each firm faces the following demand function:

$$x(v) = X[p(v)]^{-\sigma}, \quad x^*(v) = X^*[p^*(v)]^{-\sigma}, \quad \sigma > 1, \tag{1a, b}$$

where $x(v)$ is the demand for the differentiated goods indexed by $v\,(\in V)$, V is the mass of the available goods, $p(v)$ is its price, and X is the aggregate demand. The asterisk indicates a foreign variable. Demand functions (1a, b) can be derived from CES preferences with an elasticity of substitution between varieties σ that exceeds 1. Firms are heterogeneous in terms of their productivity $\phi\,(\in [1,\infty])$. The production function of each sector of the firm with productivity ϕ (the ϕ firm) is shown as follows[3]:

$$q_D(\phi) = \phi\, l_D, \quad q_{EX}(\phi) = \phi\, l_{EX}, \quad q_{FD}(\phi) = \phi^\alpha\, l_{FD}^* \quad (0 < \alpha \le 1). \tag{2a-c}$$

The subscripts D, EX, and FD show the domestic, export, and FDI sectors, respectively, $q_i(\phi)$ is the output, and l_i (or l_i^*) is the level of employment in sector i $(i = D, EX, FD)$. Productivity levels are independent and are drawn from a cumulative distribution function $G(\phi)$. The production function of the FDI sector (2c) is a linear function of ϕ in the case $\alpha = 1$, but it becomes a strictly concave function of ϕ in the case $0 < \alpha < 1$ (see Fig. 1).

[3] The case $0 < \phi < 1$, which implies that the lower the level of α, the higher the productivity, is an unrealistic situation. Therefore, we examine only the case $\phi \in [1,\infty]$ in our analysis.

Fig.1 about here

The case $0<\alpha<1$ shows a situation in which the higher the productivity (ϕ), the larger the difference between the labor productivity (q/l) of domestic production by the domestic or export sector and that of offshore production by the FDI sector. This is because the home firm with high productivity (ϕ) faces severe technological constraints in offshore production. On the other hand, the lower the productivity, the smaller this difference becomes, because the low production technology of the home firm with low productivity is easily accessible to any worker. In the next place, the case $\alpha=1$ corresponds to a situation in which the FDI sector does not face technological constraints in offshore production. Therefore, we can regard $\alpha=1$ as a case in which a home firm undertakes FDI in a developed country, which is endowed with an abundant supply of highly skilled workers and advanced production facilities, and $0<\alpha<1$ as a case in which the home firm invests in a developing country lacking in these endowments. In other words, the foreign country in our model is a developed country if $\alpha=1$ and a developing country if $0<\alpha<1$.[4] In fact, when high-tech firms of a

[4] Even if we assume $\alpha>1$, the main result is the same as that under $\alpha=1$. However, we

developed country relocate their production functions to developing countries, the overseas subsidiaries usually face technological production constraints.

The profit function of each type of the home firm is shown as follows:

$$\pi = \begin{cases} \pi_D = \left(p_D x - w l_D - f\right), & \textit{if the firm is a domestic firm,} \\ \pi_D + \pi_{EX} = \left(p_D x - w l_D - f\right) + \left(p_{EX}^* x^* - w l_{EX} - f_{EX}\right), & \textit{if the firm is an export firm,} \\ \pi_D + \pi_{FD} = \left(p_D x - w l_D - f\right) + \left(p_{FD}^* x^* - w^* l_{FD}^* - f_{FD}\right), & \textit{if the firm is an FDI firm,} \end{cases} \tag{3a-c}$$

where π_i is the profit of sector i $(i = D, EX, FD)$. Each sector of all differentiated-goods firms shares the same fixed capital investment, f, f_{EX}, and f_{FD}, respectively, but the sectors have different productivity levels, indexed by ϕ. We assume $f < f_{EX} < f_{FD}$ in the same way as Helpman et al. (2004) did. The per-unit trade cost is modeled on the iceberg formulation; that is, the export of one unit of goods requires $\tau > 1$ units of goods. The ϕ firm takes the wage rates w and w^* as given and determines the prices to maximize the profit (3a-c) subject to (1a, b), (2a-c), $x = q_{ND}$, and $\tau x^* = q_{EX}$ in the export sector and $x^* = q_{FD}^*$ in the FDI sector; we have

$$p_D(\phi) = w/\rho\phi, \quad p_{EX}^*(\phi) = \tau w/\rho\phi, \quad p_{FD}^*(\phi) = w^*/\rho\phi^\alpha \, , \tag{4a-c}$$

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limit our analysis to the case of $0 < \alpha \leq 1$ for simplicity.

where $\rho \equiv (\sigma - 1)/\sigma$. Using (4a-c), the profit of each sector (3a-c) can be rewritten as

$$\pi_D(\phi) = \left(\frac{X}{\sigma}\right)\left(\frac{\rho\phi}{w}\right)^{\sigma-1} - f, \quad \pi_{EX}(\phi) = \left(\frac{X^*}{\sigma}\right)\left(\frac{\rho\phi}{w}\right)^{\sigma-1} \tau^{-(\sigma-1)} - f_{EX},$$
$$\pi_{FD}(\phi) = \left(\frac{X^*}{\sigma}\right)\left(\frac{\rho}{w^*}\right)^{\sigma-1} \phi^{\alpha(\sigma-1)} - f_{FD}. \tag{5a-c}$$

We assume that the aggregate demand, wage, fixed cost, and elasticity of substitution are exogenously given. Under this assumption, the profit of each sector becomes an increasing function of ϕ. We define ϕ_{min} as the lowest productivity level of successful entrants, and therefore $\pi_D(\phi_{min}) = 0$. In other words, the firm with productivity $\phi \geq \phi_{min}$ begins production to serve the home market. A firm with productivity high enough to serve the foreign market determines whether it must operate as an export firm or an FDI firm. If the expected profit of the export firm is larger than that of the FDI firm ($\pi_{EX}(\phi) \geq \pi_{FD}(\phi)$), it will be an export firm. On the other hand, if $\pi_{FD}(\phi) \geq \pi_{EX}(\phi)$, it will be an FDI firm. We also define $\phi_{EX\,min}$ as the lowest productivity level of the export firm; therefore, $\pi_{EX}(\phi_{EXmin}) = 0$.

2.2 FDI flows to developed countries (the case of $\alpha = 1$)

We examine the relationship between productivity and production patterns when the foreign country is a developed country ($\alpha = 1$). We assume $X = X^*$ in this section for simplicity, but this assumption does not affect the outcome of proposition 1 presented subsequently. As noted above, the FDI sector does not face technological constraints in offshore production in this case. Therefore, the profit function of each sector can be illustrated as in Fig. 2.

Fig. 2 about here

Where $X = X^*$, ϕ_{min} is always lower than $\phi_{EX\,min}$, because the fixed cost of the domestic sector is lower than that of the export sector ($f < f_{EX}$). Therefore, the firm, which has a productivity of $\phi \geq \phi_{EX\,min}$, starts exporting. Next, we find that $\pi_{EX}(\phi)$ intersects $\pi_{FD}(\phi)$ only at one point, $\tilde{\phi}$; this productivity level satisfies the condition $\pi_{EX}(\tilde{\phi}) = \pi_{FD}(\tilde{\phi})$ (see Fig. 2). The reason these two functions intersect each other only at one point can be explained as follows. The FDI sector's profit is lower than the export sector's in the range in which the productivity ϕ is relatively low ($\phi \leq \tilde{\phi}$), because the fixed cost of the FDI sector is higher than that of the export sector ($f_{EX} < f_{FD}$). In addition, the slope of the tangent of $\pi_{FD}(\phi)$ is always steeper than that of $\pi_{EX}(\phi)$, mainly because the FDI firm can save the transport cost τ. Now, we find that if a foreign country is a developed country, the home firm with a productivity of $\phi_{EX\,min} \le \phi \le \tilde{\phi}$ becomes an export firm. The highest productivity level $\phi (\ge \tilde{\phi})$ sets off FDI. This result is analogous to that of Helpman et al. (2004).

Proposition 1 Where the foreign country is a developed country ($\alpha = 1$), home firms with the highest productivity ($\tilde{\phi} \le \phi$) undertake FDI, because they do not face technological constraints in foreign country production.

2.3 FDI flows to developing countries (the case of $0 < \alpha < 1$)

Where a foreign country is a developing country with low production technology ($0 < \alpha < 1$), the profit function of each sector is shown in Fig. 3.

Fig. 3 about here

The slope of the tangent of $\pi_{FD}(\phi)$ is steeper than that of $\pi_{EX}(\phi)$ in the range in which the productivity ϕ is at a lower level, because the FDI firm can save transport and labor costs, and does not face significant technological constraints. However, as shown in Fig. 3, $\pi_{EX}(\phi)$ intersects $\pi_{FD}(\phi)$ at two points, $\tilde{\phi}_1$ and $\tilde{\phi}_2$ (see Appendix A.1). A home firm with a productivity of $\phi_{EX\,min} \le \phi \le \tilde{\phi}_1$ becomes an export firm, and one with a productivity of $\tilde{\phi}_1 \le \phi \le \tilde{\phi}_2$ becomes an FDI firm.[5] In addition, a firm with the highest level of productivity, $\tilde{\phi}_2 \le \phi$, chooses exports rather than FDI, because the profit-decreasing effect attributed to technological constraints in offshore production dominates the profit-increasing effect of several kinds of cost savings from FDI. This is an interesting finding. From our theoretical analysis, we find that highest productivity firms hesitate to undertake FDI in developing countries, which is contrary to the prediction of many previous studies.

Proposition 2 Where the foreign country is a developing country ($0 < \alpha < 1$), home firms with the second level of productivity, $\tilde{\phi}_1 \le \phi \le \tilde{\phi}_2$, choose FDI, and those with the highest level of productivity, $\tilde{\phi}_2 \le \phi$, choose exports. This result is mainly due to technological constraints in offshore production.

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[5] It should be noted that the levels of fixed costs f_{EX} and f_{FD} that give rise to conditions $\tilde{\phi}_1 \le \phi_{EX\,min}$ and $\pi_{FD}(\tilde{\phi}_1) \le 0$ do exist. In this case, home firms with productivity $\phi_{EX\,min} \le \phi \le \tilde{\phi}_2$ become the FDI firms.

3. Empirical verification

3.1 Empirical hypotheses

In this section, we verify our findings from the theoretical analysis empirically. First, we use descriptive statistics to understand the real conditions about the relationship between the productivity of Japanese firms and their location choices. We use 2008 data on individual firms from "Kaigai Shinsyutsu Kigyou Souran" (in Japanese), published by Toyo Keizai, Inc. Entities surveyed in this database are Japanese firms that hold at least 20% of the shares of more than two foreign affiliates. We selected for analysis data on the key industries of Japan: general machinery, electronic and electrical equipment, precision instruments, and transport equipment. The target regions for FDI flows are defined as follows: Member countries of G8 or OECD, as well as four newly industrialized economies (NIEs), except Japan, Mexico, and Turkey, were identified as developed countries. Countries classified as ODA recipients in the DAC List approved in August 2009 are considered as developing countries (see Appendix A.2 for more information on the data).[6] Note that China, except Hong Kong, is considered as a

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[6] The 30 developed countries identified are Australia, Austria, Belgium, Canada, Czech

developing country.

Table 1 about here

Table 1 suggests the following distinctions about firms' behavior. Of 450 Japanese firms, 426 undertake FDI in developed countries, and their average productivity is 34.273 (million yen per employee). Productivity is defined as $sales/number\ of\ employees$. On the other hand, the 24 firms with no FDI in developed countries have an average productivity of 27.799. We find that the average productivity of a firm undertaking FDI in developed countries is higher than that of a firm with no FDI in these countries. Of 450 firms, 412 do FDI in developing countries, and their average productivity is 32.669. The other 38 firms with no FDI in developing countries, and their average productivity is 47.576. We also find that the average productivity of firms with FDI in developing countries is much lower than that of firms with no FDI in developing countries. These findings are consistent with the two propositions

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Republic, Denmark, Finland, France, Germany, Greece, Hong Kong, Hungary, Ireland, Italy, Luxembourg, the Netherlands, New Zealand, Norway, Poland, Portugal, Russia, Singapore, the Slovak Republic, South Korea, Spain, Sweden, Switzerland, Taiwan, the United Kingdom, and the United States. Mexico and Turkey are classified as ODA recipients in the DAC List; therefore, we eliminate them from the list of developed countries.

presented in section 2; we can therefore propose the following empirical hypotheses:

Hypothesis 1 The higher the productivity of the firm, the more likely is the firm to undertake FDI in developed countries.

Hypothesis 2 The higher the productivity of the firm, the less likely is the firm to undertake FDI in developing countries.

3.2 Empirical specification

To estimate hypotheses 1 and 2, we verify the following equations by using the binomial probit model.[7]

$$y_j^{DEV} = \gamma^{DEV} + \beta^{DEV} Productivity_j + \sum_M \delta_M^{DEV} Dummy_{Mj} + \varepsilon_j^{DEV} . \qquad (6a)$$

[7] Some readers may think that the multinomial probit model is a more pertinent tool for our verification, but it is not. To verify hypothesis 1, we need to estimate the probabilities that "firms invest in developed countries only and in both developed and developing countries." However, if we use the multinomial probit model, each of the probabilities—that "firms invest only in developed countries" and that "firms invest in both developed and developing countries"—is estimated separately. The same can be said for the verification of hypothesis 2. Therefore, we use the binomial probit model for our estimation.

$$y_j^{LDEV} = \gamma^{LDEV} + \beta^{LDEV} Productivity_j + \sum_M \delta_M^{LDEV} Dummy_{Mj} + \varepsilon_j^{LDEV} . \quad (6b)$$

The subscripts j and M show the j th firm and industry M, and y_j^z ($z = DEV, LDEV$) is the variable indicating whether the j th firm undertakes FDI in country z or not; it takes the value of 0 or 1. The superscripts DEV and $LDEV$ indicate developed and developing countries, respectively. For example, $y_j^{DEV} = 1$ shows that the j th firm undertakes FDI in developed countries. A zero instead of 1 would indicate the firm has no FDI in developed countries. $Productivity$ is labor productivity, $Dummy_M$ is the dummy variable of industry M, and ε is the disturbance term. We estimate β, γ, and δ in equations (6a, b) using probit regression, controlling for the difference between industries, and clarify the relationship between the firm's productivity and the probability of its undertaking FDI in each (developed or developing) region.

3.3 Empirical results

Hypotheses 1 and 2 are verified by the estimated values of β^{DEV} and β^{LDEV}. Hypothesis 1 and 2 are accepted if $\beta^{DEV} > 0$ and $\beta^{LDEV} < 0$ cannot be rejected, respectively. The estimation results are shown in table 2.[8]

Table 2 about here

The value of β^{DEV} is 0.011, and the significance level of this result by an asymptotic *t*-test is 10%. Hence $\beta^{DEV} > 0$ cannot be rejected and hypothesis 1 is accepted. Therefore, the higher the firm's productivity, the more likely is the firm to undertake FDI in developed countries. Next, the value of β^{LDEV} is −0.009 at a 5% significance level. Therefore, hypothesis 2 is also supported, and we find that the higher the firm's productivity, the less likely is the firm to undertake FDI in developing countries. We now confirm that both the hypotheses derived from the theoretical propositions are supported empirically.

3.4 Robustness

We now add the independent variables such as size of the firm and R&D intensity to equations (6a, b) in order to control for the size and R&D investment of the firm. Size of the

[8] We use E-views 6.0 in estimation. We control for heteroskedasticity in the estimation of probit regression.

firm is defined as the number of employees in the firm and R&D intensity as the ratio of R&D expenditure to sales. The estimation results are shown in table 3.

Table 3 about here

The value of β^{DEV} is 0.028, and statistically significant at 1% level. The estimation coefficient of R&D intensity is nonnegative, and statistically significant at 1% level. These results suggest that hypothesis 1 is supported; that is, R&D-intensive (high-tech) firms tend to undertake FDI in developed countries. This finding is contrary to the suggestion of Norbäck (2001). On the other hand, the value of β^{LDEV} is −0.007, and statistically significant at 10% level. Further, the estimation coefficient of R&D intensity is negative, and statistically significant at 1% level. These results show that hypothesis 2 is supported. Therefore, we also find that R&D-intensive (high-tech) firms are not predisposed to undertaking FDI in developing countries.

4. Conclusion

We examine the relationship between the location choices of MNEs and their productivity by using a heterogeneous firm model with technological constraints factored in, and obtain the following results. First, we find that home firms with the highest productivity choose to do FDI in developed countries. This result is analogous to that of many previous studies like Helpman et al. (2004) and Nishiyama and Yamaguchi (2010). Second, we also find that high-productivity firms are not predisposed to undertaking FDI in developing countries, contrary to Helpman et al.'s (2004) observations. This remarkable finding results from the technological constraints of offshore production in developing countries, which several previous studies dealing with heterogeneous firm models have not considered.

In addition, we verify our findings by theoretical analysis, empirically, using Japanese firm-level data, and confirm that high-tech (high-productivity or R&D-intensive) Japanese firms tend to undertake FDI in developed countries but hesitate to invest in developing countries. These findings explain why not many centers of high-tech industry similar to Silicon Valley exist in developing countries.

Appendix

A.1 Proof of the possibility that π_{EX} intersects π_{FD} at two points

We prove that the profit function of the export sector, $\pi_{EX}(\phi)$, intersects that of the FDI sector, $\pi_{FD}(\phi)$, at two points. Differentiating (5b, c) with respect to ϕ, we have

$$\pi_{EX}{}'(\phi) \equiv \frac{d\pi_{EX}(\phi)}{d\phi} = \tau^{-(\sigma-1)}\ (\sigma-1)\left[\frac{\rho}{w}\right]^{\sigma-1}\left[\frac{X^*}{\sigma}\right]\phi^{\sigma-2} > 0\,, \tag{A1}$$

$$\pi_{FD}{}'(\phi) \equiv \frac{d\pi_{FD}(\phi)}{d\phi} = \alpha\left[\frac{w}{w^*}\right]^{(\sigma-1)}\ (\sigma-1)\left[\frac{\rho}{w}\right]^{\sigma-1}\left[\frac{X^*}{\sigma}\right]\phi^{\alpha(\sigma-1)-1} > 0\,. \tag{A2}$$

Considering (A1, 2), we can find $\pi_{FD}{}'(1) > \pi_{EX}{}'(1)$ in the case

$$\alpha\left(\frac{w}{w^*}\right)^{(\sigma-1)} > \tau^{-(\sigma-1)} \ \leftrightarrow\ \alpha\left(\frac{w}{w^*}\right)^{(\sigma-1)}\tau^{(\sigma-1)} > 1\,. \tag{A3}$$

This shows that the slope of the tangent of (5c) at $\phi = 1$ is steeper than that of (5b). Equation (A3) corresponds to a case in which both transport costs (τ) and relative home wages (w/w^*) are higher. The larger the value of $\alpha(w/w^*)^{(\sigma-1)}\tau^{(\sigma-1)}$ in (A3), the stronger the incentive of the firm to choose FDI rather than export.

Next, the level of $\bar{\phi}$ that satisfies $\pi_{FD}{}'(\bar{\phi}) = \pi_{EX}{}'(\bar{\phi})$ can be derived as

$$\bar{\phi} = \left[\alpha\left(\frac{w}{w^*}\right)^{(\sigma-1)}\tau^{(\sigma-1)}\right]^{\frac{1}{(\sigma-1)(1-\alpha)}}.$$

If condition (A3) is satisfied, $\bar{\phi}$ must exceed 1. We also find that $\pi_{EX}{}'(\phi)$ would be larger than $\pi_{FD}{}'(\phi)$ at some stage, as $\phi(\geq 1)$ increases, because

$(\sigma-2)-\{\alpha(\sigma-1)-1\}=(1-\alpha)(\sigma-1)\geq 0$ (see the exponents of ϕ in (A1) and (A2)). Therefore, we obtain $\pi_{FD}{}'(\phi)\geq \pi_{EX}{}'(\phi)$ in the case $1\leq \phi \leq \bar{\phi}$, and $\pi_{FD}{}'(\phi)\leq \pi_{EX}{}'(\phi)$ in the case $1\leq \bar{\phi} \leq \phi$ under condition (A3). We now confirm that $\pi_{EX}(\phi)$ can intersect $\pi_{FD}(\phi)$ at two points as shown in Fig. 3, if the difference between the fixed capital cost levels f_{EX} and f_{FD} is not significant.

A.2: Data set

We have analyzed the key industries of Japan (general machinery, electronic and electrical equipment, precision instruments, and transport equipment). In section 3, we use data on the characteristics of Japanese MNEs from "Kaigai Shinsyutsu Kigyou Souran 2008," published by Toyo Keizai, which has researched the FDI status of Japanese MNEs as of November 2007. We define developed countries as member countries of G8 or OECD, as well as four NIEs (South Korea, Singapore, Taiwan, and Hong Kong), except Japan, Mexico, and Turkey, and developing countries as those classified as ODA recipients in the DAC List. We classify investment destinations of Japanese MNEs into developing and developed countries. We define "productivity," "size," and "R&D intensity" as sales per employee, number of employees, and the ratio of R&D expenditure to sales, respectively, in fiscal 2007. These are available in the firms' annual security reports. Table A.1 summarizes the descriptive statistics used in the empirical estimations.

Table A.1 about here

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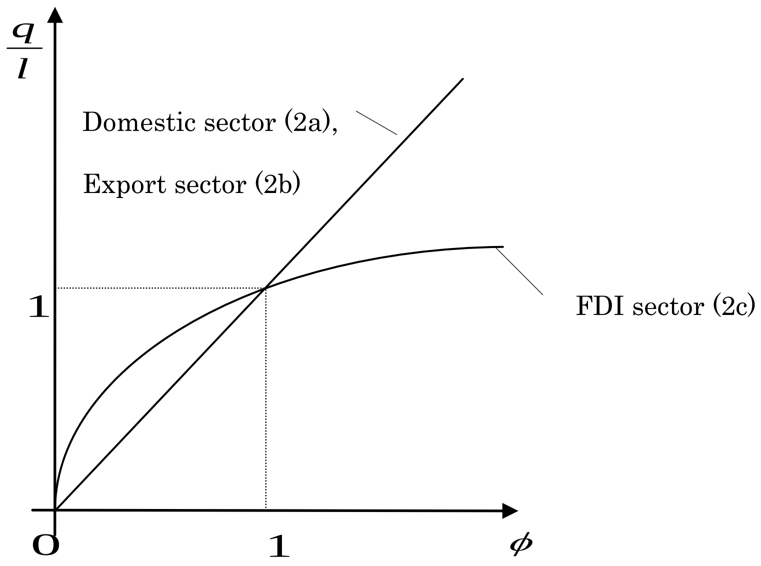

Fig.1 Production function of each sector

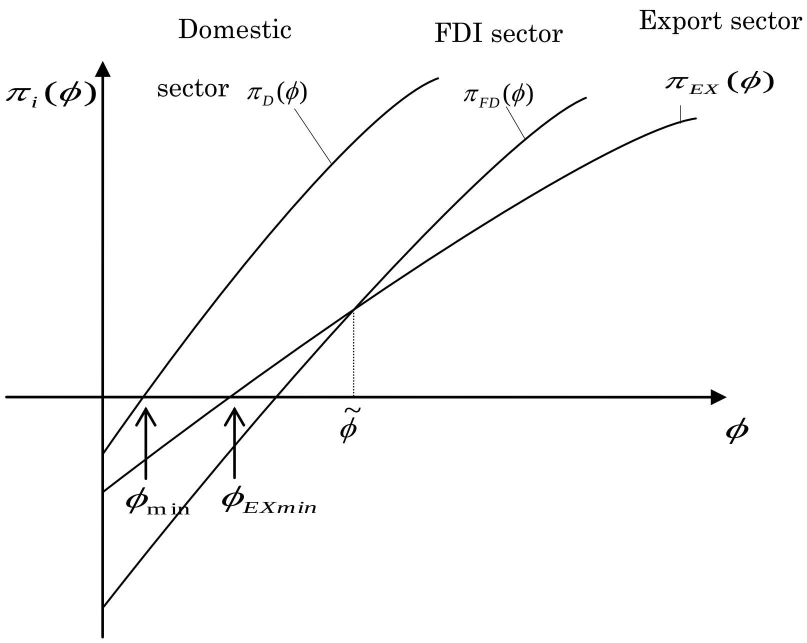

Fig.2 Profit function of each sector ($\alpha = 1$)

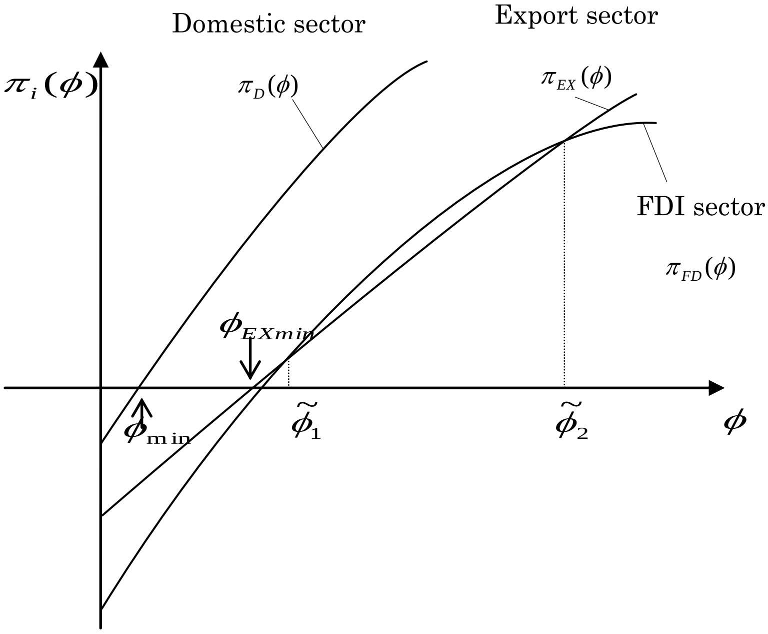

Fig.3 Profit function of each sector ($0 < \alpha < 1$)

Table 1

Distinctions about firm's behavior

	Average productivity	Number of firms
Firms undertaking FDI in developed countries	34.273	426
Firms with no FDI in developed countries	27.799	24
Firms undertaking FDI in developing countries	32.669	412
Firms with no FDI to developing countries	47.576	38
All firms	33.928	450

Table 2

Binominal probit regression of firm's location choice

	Developed country (6a)			Developing country (6b)		
Variable	Coef.		Standard errors	Coef.		Standard errors
Constant (γ)	1.121	***	0.292	2.314	***	0.355
Productivity (β)	0.011	*	0.006	−0.009	**	0.004
General Machinery Dummy	−0.011		0.279	−0.476		0.350
Electronic and Electrical Equipment Dummy	0.399		0.278	−0.743	**	0.332
Precision Instrument Dummy	−0.046		0.380	−1.041	**	0.413
Observations	450			450		
Log likelihood	−90.648			−121.106		

Note: Reference group is the transport equipment industry.

* Statistically significant at the 10% level of significance.

** Statistically significant at the 5% level of significance.

*** Statistically significant at the 1% level of significance.

Table 3

Binominal probit regression of location choice with additional variables (the size and R&D investment of the firm)

	Developed country			Developing country		
Variable	Coef.		Standard errors	Coef.		Standard errors
Constant (γ)	−1.009	**	0.477	1.198	***	0.451
Productivity (β)	0.028	***	0.009	−0.007	*	0.004
Size (employee)	0.0005	***	0.0001	0.0006	***	0.0001
R&D intensity	24.811	***	7.212	−11.163	***	3.276
General Machinery Dummy	0.649	*	0.371	0.097		0.438
Electronic and Electrical Equipment Dummy	0.366		0.387	−0.138		0.430
Precision Instrument Dummy	0.112		0.517	−0.173		0.497
Observations	447			447		
Log likelihood	−63.117			−86.877		

Note: The firm with no R&D expenditure is omitted from this sample.

Reference group is the transport equipment industry.

* Statistically significant at the 10% level of significance.

** Statistically significant at the 5% level of significance.

*** Statistically significant at the 1% level of significance.

Table A.1

Descriptive statistics

Variable	Mean	Standard deviation	Observation
Developed country	0.947	0.225	450
Developing country	0.916	0.278	450
Productivity	33.928	24.912	450
General Machinery Dummy	0.304	0.461	450
Electronic and Electrical Equipment Dummy	0.444	0.497	450
Precision Instrument Dummy	0.073	0.261	450
Developed country	0.949	0.221	447
Developing country	0.915	0.279	447
Productivity	33.816	24.934	447
Number of employees	12641.030	35949.180	447
R&D intensity	0.034	0.029	447
General Machinery Dummy	0.302	0.460	447
Electronic and Electrical Equipment Dummy	0.445	0.498	447
Precision Instrument Dummy	0.074	0.262	447

Note: The firm with no R&D expenditure is omitted from this sample.