

Endogenous FDI Spillovers: Do You Want to Keep Your Recipe to Yourself?

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Abstract

This paper aims to explore the role of spillovers in the strategic choice for a MNE in a duopoly model, especially focusing on endogenous FDI spillovers with spillover-prevention costs. After discussing the exogenous spillover case, this paper shows that with a quadratic spillover-prevention cost function, the FDI-performing firm may choose a positive level of spillovers, which is lower than the exogenous level, and also shows the determinants of such optimal spillovers and how endogenizing spillovers affect the home firm's decision on plant location. As extensions of the model, this paper explores a n FDI-performing firm case and a m -foreign firm case separately, and shows that as the numbers of the home firms goes infinity, the cutoff value of trade cost converges to that with exogenous spillovers. On the other hand, this paper shows that as the numbers of the foreign firms goes infinity, the cutoff value of trade cost can be either larger or smaller than that with exogenous spillovers.

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1 Introduction

From the 1990s, many firms in developed countries have performed FDI in China and other east and southeast Asian countries. However, some companies have chosen to keep their production facilities in their home countries, although they are very competitive and sell their products in many countries, including the FDI host countries cited above. For instance, some Japanese manufacturers producing digital consumer electronics such as large-screen liquid crystal display (LCD) TV and digital camera keep their production facilities in Japan, reported that they intent not to disclose their technology to rival companies abroad. At the same time, FDI host countries want multinational enterprises (MNEs) to transfer their superior technology to domestic counterparts. Some MNEs reply to host countries' request positively while others do negatively. The latter case sometimes let MNEs to hesitate to perform FDI. What causes such a difference? One concept that helps us consider these two problems together is FDI spillovers, i.e. a positive externality from MNEs to firms in the FDI host countries.

In the international trade literature, various factors are discussed as causes of outward FDI, such as marginal-cost differences between the home and FDI host countries associated with a fixed cost of FDI (Horstmann and Markusen 1992), expectation of demand growth in the FDI host country (Rob and Vettas 2003), and heterogeneity in productivity among domestic firms (Helpman et al. 2004). About FDI spillovers, many empirical studies exist (Dimelis 2005, for instance), although the effects of internal FDI on productivity of domestic firms in various countries are mixed.

Two trade-theory studies are highly related with this article.¹ Bjorvatn and Eckel (2006) develop a two-country, two-firm model in which firm a in country A has a lower constant marginal cost than firm b in country B . They examine the effects of exogenous trade costs, spillovers, and technology mobility between the two countries on entry of the two firms into the foreign markets. They show the possibilities of technology-sourcing FDI by firm b , and more interestingly, strategic FDI by firm a to prevent technology sourcing, despite FDI spillovers to firm b . Grünfeld (2006) develops a three-period model with two countries and two firms where firm d serves only market D while firm f may serve markets D and F . It is assumed that a firm's marginal cost depends on R&D investments by itself and the rival firm in case of FDI by firm f , and that FDI spillovers gets larger as its own R&D investment gets larger. The author argues that the second assumption is to capture the so called "absorptive capacity" of FDI spillovers, in which many empirical studies attempt to measure. The most interesting result is that for firm f , weak and strong absorptive capacity effects favor exports while medium-sized absorptive capacity effects favor FDI.

This paper aims to explore the role of FDI spillovers in the strategic choice for MNEs. Especially, this paper focuses on endogenous FDI spillovers with positive

¹Another line of the theoretical literature about R&D spillovers is in industrial organization, such as research joint venture (Greenlee 2005, for instance) and spatial model a la Hotelling in terms of product quality (Piga and Poyago-Theotoky 2005).

spillover-prevention costs. That is, this paper examines the case when a MNE may determine the level of spillovers with FDI by itself but must pay some costs at the same time. If no spillovers is not free, the MNE might seek an optimal level of spillovers with FDI, which could be positive.

The most important contribution of this paper will be to discuss endogenous FDI spillovers with the MNE's decision on the plant location, i.e. exports or FDI. The relationship between FDI spillovers and plant location is also discussed by Both Bjorvatn and Eckel (2006) and by Grünfeld (2006), but this paper differs from them in the following two things. First, their focus is on the international transactions among EU countries, especially developed ones. On the other hand, this paper considers a situation where a firm in a developed country enters a market of a developed country either by exports or FDI and FDI spillovers have only one direction, from low-cost to high cost firms. This setting is based on the observations on MNEs' behavior in east and southeast Asian countries discussed above. Their models include the case that this paper discusses, and thus are more general (including technology-sourcing FDI, for instance). However, such a simple setting makes the model of this paper very tractable and many extensions are possible. For instance, This paper extends its duopoly model in which more than one firm in either FDI source or FDI host countries exist, while the two papers mentioned above develop only duopoly models.

Second, the specifications of FDI spillovers are different. Bjorvatn and Eckel (2006) considers only exogenous FDI spillovers because their focus is on technology sourcing associated with technology transfer from FDI-host to FDI-source countries. Grünfeld (2006)'s assumption for endogenous spillovers is similar with that in this paper; a parameter capturing effectiveness for investment is important. Besides this parameter, a parameter capturing a cost disadvantage of the firm in the FDI-host country is also important in this paper.

This paper aims to explore the role of spillovers in the strategic choice for a MNE in a duopoly model, especially focusing on endogenous FDI spillovers with spillover-prevention costs. After discussing the exogenous spillover case, this paper shows that with a quadratic spillover-prevention cost function, the FDI-performing firm may choose a positive level of spillovers lower than the exogenous level, and also shows the determinants of such optimal spillovers and how endogenizing spillovers affect the home firm's decision on plant location. As extensions of the model, this paper explores a n FDI-performing firm case and a m -foreign firm case separately, and shows that as the numbers of the home firms goes infinity, the cutoff value of trade cost converges to that with exogenous spillovers. On the other hand, this paper shows that as the numbers of the foreign firms goes infinity, the cutoff value of trade cost can be either larger or smaller than that with exogenous spillovers.

The rest of this article is arranged as follows. Section two describes the model. First as a benchmark, exogenous spillovers are discussed. Then the endogenous case with a quadratic spillover-prevention cost function is analyzed. Section three extends the model to oligopoly; n home firm and m foreign firm cases. Finally, section four concludes this paper.

2 Model

This paper develops a duopoly model based on Horstmann and Markusen (1992), who analyze endogenous plant location in a two-firm, two-market model. Consider two countries, home and foreign, and a home firm plans to enter the foreign market either by exports or FDI. Assume that to export products to the foreign country, the home firm must pay a unit trade cost of t , which is an incentive for the home firm to perform FDI. After the decision on plant location, the home firm competes with a foreign firm by quantity of the same product. An inverse demand in the foreign country is assumed; $P = A - Q$ where P is the price of the product, Q is the total quantity, and A is a positive constant.

Suppose that marginal costs of the both firms are constant. The marginal cost of the home firm is c , and that of the foreign firm is $(1 + d)c$, where d is a positive constant. Thus, the home (foreign) firm has a cost (dis)advantage and the degree of its (dis)advantage is captured by the parameter d . Suppose that FDI reduces the cost disadvantage to the foreign firm by s while exports does not at all. One might assert that exports also make some spillovers although the degree is lower than that with FDI. However, for the tractability of the model, no spillovers with exports are assumed in this paper. After FDI, the marginal cost of the foreign firm is $(1 + d - s)c$. Such a decrease in the marginal cost is referred as ‘‘FDI spillovers’’ in this paper, and it makes FDI less attractive for the home firm.

First, as a benchmark, a case of exogenous spillovers is discussed. In this case, a degree of spillovers s is exogenous for both the home and foreign firms, as well as the trade cost t and other exogenous variables. Then endogenous spillovers, which the home firm may determine, are examined.

2.1 Benchmark: Exogenous Spillovers

Suppose that the level of spillovers due to FDI is s_0 and it is given to both the home and foreign firms. Then, the profits of the home and foreign firms in each of the plant location of the home firm are as follows.

$$\pi_h = \begin{cases} (A - x - y)x - (c + t)x & \text{No FDI, i.e. exports,} \\ (A - x - y)x - cx & \text{FDI.} \end{cases} \quad (1)$$

$$\pi_f = \begin{cases} (A - x - y)y - (1 + d)cy & \text{No FDI,} \\ (A - x - y)y - (1 + d - s_0)cy & \text{FDI.} \end{cases} \quad (2)$$

π_h and π_f are profits of the home and foreign firms respectively. x and y are quantity produced by the home and foreign firms respectively.

From the first order conditions, the quantity produced by the each firm in the each case is the following. When the home firm chooses exports (Case E),

$$x^E = \frac{A + (-1 + d)c - 2t}{3}, \quad (3)$$

$$y^E = \frac{A + (-1 - 2d)c + t}{3}. \quad (4)$$

On the other hand, when the home firm chooses FDI (Case F),

$$x^F = \frac{A + (-1 + d - s_0)c}{3}, \quad (5)$$

$$y^F = \frac{A + (-1 - 2d + 2s_0)c}{3}. \quad (6)$$

By inserting the equilibrium outputs in each case to the profits (1) and (2), it is shown that $\pi_h = (x^i)^2$, where $i = E, F$, and that $\pi_f = (y^j)^2$, where $j = E, F$. This implies that comparing the outputs of a firm in the two cases is enough to compare the profits in the two cases. From equations (3) and (5), equilibrium outputs of the home firm in the two cases, the cutoff value of the trade cost is

$$t_c = \frac{s_0 \cdot c}{2}. \quad (7)$$

The home firm chooses FDI if the trade cost is higher than t_c . Although equation (7) is a condition for FDI with exogenous spillovers, it is interesting to compare this condition with the counterpart in case of endogenous spillovers, discussed in the next subsection.

2.2 Endogenous Spillovers

Suppose that before deciding the plant location, the home firm may determine the degree of FDI spillovers s by itself. If perfect prevention of spillovers, i.e. decreasing the level of spillovers from s_0 to zero, is possible without any costs, it is obvious from equation (5), the equilibrium output of the home firm in case of FDI, that the home firm definitely does so. However, if making the level of spillovers lower than s_0 needs additional costs, an optimal value of s , which is still positive, might exist.

Assume that the spillover-prevention cost function is quadratic and that making the level of spillovers lower than s_0 , the level of FDI spillovers without any action by the home firm, costs more. Then the profits of the home firm in case of FDI are

$$(A - x - y)x - cx - e(s_0 - s)^2$$

where e is a positive constant. The formulae of the profits of the home and foreign firms in case of exports are not changed, due to the assumption of zero spillovers with exports. On the other hand, in case of FDI, the after-spillover marginal cost of the foreign firm is now $(1 + d - s)cy$, because the level of the spillovers is endogenously determined. Now the model has two periods; decision on the degree of spillovers in period one, and plant location and quantity competition in period two. The model is solved by backward induction.

Note that whatever the level of s is, if the profits with exports are higher than those with FDI, the home firm chooses exports. In such a case, the investment for spillover prevention will not be realized.

2.2.1 Period Two: Plant Location and Quantity Competition

In period two, the home firm chooses its optimal quantity associated with its optimal plant location, and the foreign firm chooses its optimal quantity. These decisions are made for a given level of spillovers with FDI, determined by the home firm in period one. This implies that the first order conditions in period two are exactly the same as those in the benchmark case, i.e. the exogenous spillovers. Thus, equations (3) to (6), the equilibrium outputs of the two firms with the exogenous spillovers, hold with the endogenous spillovers too, although s_0 is replaced by s .

2.2.2 Period One: Optimal Degree of Spillovers with FDI

Substituting the equilibrium outputs of the two firms in case of FDI (equations 5 and 6) into the profits of the two firms (the second line of equations 1 minus $e(s_0 - s)$ and the second line of equation 2) yields the profits of the two firms in period one if the home firm chooses FDI in period two;

$$\pi_h^{Period\ One} = \left\{ \frac{A + (-1 + d - s)c}{3} \right\}^2 - e(s_0 - s)^2 \quad (8)$$

$$\pi_f^{Period\ One} = \left\{ \frac{A + (-1 - 2d + 2s)c}{3} \right\}^2 \quad (9)$$

The home firm chooses s to maximize its profits. From the first order condition, the level of s maximizing the profits of the home firm is

$$s^* = \frac{9es_0 - c\{A + (-1 + d)c\}}{9e - c^2}. \quad (10)$$

s^* may be positive.² The lower bound for s^* is zero due to the definition of the spillovers. The prevention-cost parameter e have a positive effect on s^* . When the spillover prevention costs more, the home firm must allow more spillovers to save costs. The demand parameter A and the cost advantage parameter d have negative effects on s^* . One possibility for these negative effects is that either a larger A or a larger d implies a larger profit opportunity. Thus, the home firm attempts to keep its cost advantage to utilize such an opportunity. Finally, it is worth noting that $s_0 > s^*$, i.e. the home firm makes the level spillovers lower than the exogenous level.³

Inserting s^* into equations (8) and (9) yields equilibrium profits of the two firms, denoted by π_h^* and π_f^* respectively;

$$\pi_h^* = \frac{\{A + (-1 + d - s_0)c\}^2 e}{9e - c^2}. \quad (11)$$

² s^* is positive if (1) $e > \frac{c^2}{9}$ and if (2) $s_0 > \frac{c\{A + (-1 + d)c\}}{9e}$. The first inequality is necessary for the second order condition to hold, and thus is assumed in this paper. The second inequality is likely to hold if $9e$ is much larger than c or if A is not too large. The second inequality is also assumed in the rest of this paper.

³ $s_0 - s^* = \frac{c}{9e - c^2} \{A + (-1 + d - s_0)c\}$. The value inside the curly brackets is positive by the assumption that the output with FDI is positive (equation 5).

$$\pi_f^* = \left\{ \frac{(A - c)(3e - c^2) + (-d + s_0) \cdot 6ce}{9e - c^2} \right\}^2 \quad (12)$$

Note that by choosing s^* , the home firm increases its profits despite the costs of spillover prevention. If the home firm does not change the level of spillovers at s_0 , from equation (5), its profits are $\frac{1}{9}\{A + (-1 + d - s_0)c\}^2$, which is lower than the profits with $s = s^*$ (equation 11)

If the level of FDI spillovers is endogenized, the value of trade cost equating the profits of the two locational modes is also changed. When the level of spillovers is equal to s_0 , from equation (7), the cutoff level of trade cost, denoted by t_c , is $\frac{s_0 \cdot c}{2}$. With endogenous spillovers, such a cutoff level is the solution for the following equation;

$$\frac{\{A + (-1 + d - s_0)c\}^2 e}{9e - c^2} = \frac{\{A + (-1 + d)c - 2t\}^2}{9}.$$

The left hand side is the profits with endogenous FDI spillovers (equation 11), and the right hand side is the profits with exports, equal to the squared outputs (equation 3). The solution for the above equation, denoted by t_c^* , is

$$t_c^* = \sqrt{\frac{9e}{9e - c^2}} \cdot \frac{s_0 \cdot c}{2} + \left(1 - \sqrt{\frac{9e}{9e - c^2}}\right) \frac{A + (-1 + d)c}{2}. \quad (13)$$

It is shown that $t_c^* < t_c = \frac{s_0 \cdot c}{2}$, which implies that the cutoff value of trade cost is lower with endogenous FDI spillovers. The following proposition summarizes the results.

Proposition 1 *With a quadratic cost function of FDI-spillover prevention, endogenizing spillovers decreases the threshold of the trade cost for FDI.*

Proof $t_c^* < t_c$ is changed to $A + (-1 + d - s_0)c > 0$, which holds by the assumption that the output with FDI is positive (equation 5) QED.

Proposition 1 implies that endogenizing spillovers makes FDI more likely, despite the costs of spillover prevention. The cutoff value t_c^* has two terms. The first term captures the effect of spillover-prevention costs, which rises the threshold for FDI. The second term describes the effect of profit opportunity with FDI, which lowers the threshold. In the duopoly case, the second effect dominates the first one. However, as the model is extended to oligopoly in the next section, interesting results arise.

3 Effects of Market Structure

So far the case of duopoly, i.e. one home firm and one foreign firm, is discussed. As extensions of the model, consider cases when more than one firm exist either in the home or foreign countries. In the former case, how to formulate FDI spillovers is an important question. The latter case may show how the market structure in the FDI host country affects the decisions on the plant location and FDI spillovers by the home firm.

3.1 n Home Firms

Suppose that $n(> 1)$ identical firms exist in the home country and they play the two-period location-production game discussed in the last section.

It seems plausible that the degree of spillovers increases as more home firms perform FDI. However, the upper bound for the degree of spillovers is s_0 , the degree of FDI spillovers without home firm's prevention efforts. Therefore, assume the following structure of FDI spillovers, i.e. the average degree of spillovers among the home firms;

$$s = \frac{1}{n} \sum_{j=1}^n s_j$$

where s_j is the degree of spillovers from home firm j ($j = 1, \dots, n$). With this formula of FDI spillovers, the profits of home firm i and foreign firm when all of the home firms choose FDI are as follows.

$$\pi_{h_i} = (A - \sum_{j=1}^n x_j - y)x_i - cx_i - e(s_0 - s_i)^2. \quad i = 1, \dots, n. \quad (14)$$

$$\pi_f = (A - \sum_{j=1}^n x_j - y)y - (1 + d - \frac{1}{n} \sum_{j=1}^n s_j)cy. \quad (15)$$

From the first order conditions in period two with an assumption that the all home firms chooses the same plant location, the equilibrium outputs of the home firm i and the foreign firm are as follows.

$$x_i^F = x^F = \frac{A + (-1 + d - s)c}{n + 2}. \quad i = 1, \dots, n. \quad (16)$$

$$y^F = \frac{A + (-1 - 2d + 2s)c}{n + 2}. \quad (17)$$

The equilibrium outputs in case of exports are derived by replacing "3" in the denominators of the output equations (3) and (4) with $n + 2$. Substituting the equilibrium outputs (equations 16 and 17) into the profits of the home firm i (equation 14) yields its objective function in period one.

$$\pi_{h_i}^{Period\ One} = \left[\frac{A + \left(-1 + d - \frac{1}{n} \sum_{j=1}^n s_j\right)c}{n + 2} \right]^2 - e(s_0 - s_i)^2. \quad i = 1, \dots, n. \quad (18)$$

From the first order conditions with respect to s_i , a reaction function for the home firm i with respect to the sum of spillovers from the all other home firms is as follows;

$$s_i = \frac{n^2(n + 2)^2 \cdot es_0 - n \cdot c\{A + (-1 + d)c\}}{n^2(n + 2)^2 \cdot e - c^2} + \frac{c^2}{n^2(n + 2)^2 \cdot e - c^2} \sum_{j \neq i} s_j. \quad i = 1, \dots, n. \quad (19)$$

Assume $en^2(n + 2)^2 > c^2$. This assumption corresponds to the first assumption in footnote two, i.e. the assumption for the second order condition in the duopoly

case. Note that the degree of spillovers by home firm i increases as the sum of counterparts of the all other firms increases. Therefore, FDI spillovers are strategic complements among the home firms.

From the first order conditions and the assumed symmetry of the model among the home firms, the level of FDI spillovers by the home firm i maximizing its profits is;

$$s_i^* = s^* = \frac{n(n+2)^2 \cdot es_0 - c\{A + (-1+d)c\}}{n(n+2)^2 \cdot e - c^2}. \quad i = 1, \dots, n. \quad (20)$$

Note that $s^* < 0$ increases as n increases, which implies that if more home firms enter the foreign market by FDI, the equilibrium degree of spillovers by the each firm, which is equal to the total spillovers, increases.

Does an increase in the number of the home firms affect the condition for each of the home firms to choose FDI? The cutoff value of the trade cost is the solution for the following equation;

$$\frac{\{(n+2)^2 n^2 e - c^2\} \{A + (-1+d-s_0)c\}^2 e}{\{(n+2)^2 ne - c^2\}^2} = \frac{1}{(n+2)^2} \{A + (-1+d)c - 2t\}^2.$$

The left hand side, the profits with FDI, are derived by substituting s^* (equation 20) into the objective function of the home firm i in period one (equation 18). The right hand side is the profits with exports, equal to the squared equilibrium output with exports. The cutoff value of the trade cost, denoted by t_c^{n*} , is

$$t_c^{n*} = \sqrt{\frac{(n+2)^4 n^2 e^2 - (n+2)^2 c^2 e}{\{(n+2)^2 ne - c^2\}^2}} \cdot \frac{s_0 \cdot c}{2} + \left(1 - \sqrt{\frac{(n+2)^4 n^2 e^2 - (n+2)^2 c^2 e}{\{(n+2)^2 ne - c^2\}^2}}\right) \frac{A + (-1+d)c}{2}. \quad (21)$$

When $n = 1$, equation (21) is reduced to equation (13). One important property with this equation is about the case when the number of the home firms goes to infinity, summarized by the following proposition.

Proposition 2 *As the number of the home firm n goes to infinity, the cutoff value of trade cost with n -home firms converges to that with exogenous spillovers, $s = s_0$.*

Proof It is enough to show that $\sqrt{\frac{(n+2)^4 n^2 e^2 - (n+2)^2 c^2 e}{\{(n+2)^2 ne - c^2\}^2}}$ converges to one as n goes to infinity. In the fraction, both the denominator and the numerator are sixth-power polynomials of n and their coefficients for n^6 is e^2 . Therefore, by de l'Hôpital's rule, the fraction converges to one. QED.

Like the duopoly case, the cutoff value has two terms; the first term is about spillover-prevention costs and the second term is about profit opportunity with FDI. As n increases, the weight on the first term gets relatively larger than the second term. Therefore, when infinitely many home firms exist, only the first term remains effective.

3.2 m Foreign Firms

Suppose that once the home firm performs FDI, the spillovers occur to all m foreign firms equally. Then, the profits of the home firm and the foreign firm j with FDI are as follows.

$$\pi_h = (A - x - \sum_{i=1}^m y_i)x - cx - e(s_0 - s)^2. \quad (22)$$

$$\pi_{f_j} = (A - x - \sum_{i=1}^m y_i)y_j - (1 + d - s)cy_j, \quad j = 1, \dots, m. \quad (23)$$

From the first order conditions in period two and the symmetry of the model among the foreign firms, the equilibrium outputs of the home firm and the foreign firm j are as follows.

$$x^F = \frac{A + (-1 + md - ms)c}{m + 2}. \quad (24)$$

$$y_j^F = \frac{A + (-1 - 2d + 2s)c}{m + 2}, \quad j = 1, \dots, m. \quad (25)$$

Substituting the equilibrium outputs (equations 24 and 25) into the profits of the home firm (equation 22) yields its objective function in period one.

$$\pi_h^{Period\ One} = \left[\frac{A + (-1 + md - ms)c}{m + 2} \right]^2 - e(s_0 - s)^2. \quad (26)$$

From the first order condition, the level of FDI spillovers maximizing the profits of the home firm is;

$$s^* = \frac{(m + 2)^2 es_0 - mc\{A + (-1 + md)c\}}{(m + 2)^2 e - m^2 c^2}. \quad (27)$$

Assume $e > \frac{m^2}{(m+2)^2}c^2$ for all $m \geq 1$, which is necessary for the second order condition to hold.⁴ Unlike the n -home-firm case, the effect of the number of the foreign firms m on s^* depends on the level of m . The derivative of s^* with respect to m is

$$\begin{aligned} \frac{\partial s^*}{\partial m} &= \frac{1}{\{(m + 2)^2 e - m^2 c^2\}^2} \\ &\quad \times [-4m(m + 2)c^2 e(d - s_0) + c(A - c)\{(m^2 - 4)e - m^2 c^2\}]. \end{aligned}$$

The sign of the effect of m is the same as the sign of the value inside the square brackets. The first term is negative. The second term is also negative if $2 \geq m$. However, the second term may positive if $m \geq 3$, and the overall effect may be positive too, if the second term is greater than the first term. For instance, if s_0 is near d , i.e. FDI erases most of the cost advantage to the home firm unless it invests

⁴The right hand side of this inequality converges to c^2 as m goes to infinity. Therefore, $e > c^2$ is assumed in the rest of this paper in order for the inequality $e > \frac{m^2}{(m+2)^2}c^2$ to hold for all $m \geq 1$.

in spillover prevention, and if e is much larger than c^2 , i.e. spillover prevention is very costly, the effect of m on s^* may be positive.

The intuition behind these results is simple. When the number of the foreign firms is small, competition in the foreign market is severe. Under such a circumstance, an increase in the number of the foreign firms makes the competition more intensifies. Although they are low-tech firms, their impact on the home firm is not negligible because of the small number of them. Thus the home firm tries to keep its cost advantage by allowing less spillovers. When the number of the foreign firms is large, the foreign market has one strong home firm and many weak foreign firms. Under this different circumstance, if the spillover prevention is very costly, the home firm allows more spillovers. However, if the spillover prevention is not costly, it is possible that the home firm allows less spillovers, like the intense competition case.

How does the cutoff value of the trade cost change as m increase? The cutoff value is the solution of the following equation;

$$\frac{e}{(m+2)^2e - m^2c^2} \{A + (-1 + md - ms_0)c\}^2 = \frac{1}{(m+2)^2} \{A + (-1 + md)c - (m+1)t\}^2.$$

The left hand side is the profits of the home firm with FDI, and the right hand side is those with exports. The solution, denoted by t_c^{m*} is

$$t_c^{m*} = \sqrt{\frac{(m+2)^2e}{(m+2)^2e - m^2c^2} \cdot \frac{ms_0 \cdot c}{m+1}} + \left(1 - \sqrt{\frac{(m+2)^2e}{(m+2)^2e - m^2c^2}}\right) \frac{A + (-1 + md)c}{m+1}. \quad (28)$$

As m goes to infinity, t_c^{m*} converges to $\sqrt{\frac{e}{e-c^2}}s_0 \cdot c + \left(1 - \sqrt{\frac{e}{e-c^2}}\right)dc$. This value can be either larger or smaller than $\frac{s_0 \cdot c}{2}$, the cutoff value with exogenous FDI spillovers ($s = s_0$). For instance, if $s_0 \geq \left(1 - \frac{1}{2\sqrt{\frac{e}{e-c^2}-1}}\right)d$, i.e. the exogenous level of spillovers erases most of the cost advantage to the home firm, then $t_c^{m*} > t_c$. The following proposition summarizes the results.

Proposition 3 *As m goes to infinity, the cutoff value of trade cost is larger than that with $s = s_0$, if $s_0 \geq \left(1 - \frac{1}{2\sqrt{\frac{e}{e-c^2}-1}}\right)d$.*

The above case would be consistent with the observations in Section one; a firm in developed country considering to enter a foreign market where many low-tech firm exists. If the firm does not choose FDI, one reason might be a high level of exogenous FDI spillovers.

4 Conclusions

First by a duopoly model and then by oligopoly models, this paper explores roles of FDI spillovers as a strategic variable for firms entering the foreign market. This

paper shows that (1) Endogenizing spillovers make FDI more likely, compared to the exogenous case, (2) n -home-firm case may have similar implications with the duopoly case, and (3) m -foreign-firm case can be different from others. It is possible that endogenized spillovers makes FDI less likely. The last result suggests the importance of the market structure on FDI spillovers

With duopoly cases, we can explore some interesting applications. First, in n -home-firm case, symmetry among home firms about plant location is assumed for tractability of the model. However, possibilities of asymmetric plant location can be examined in the two-home-firm case. Moreover, one popular policy by FDI host countries, mandating a joint venture with the foreign firm to the home firm, considered as a way of inducing more spillovers, is not discussed in this paper. Examining effects of cost heterogeneity either in source or in host countries and relating them with a joint venture may be possible further research agenda.

Another research agenda is FDI spillovers related with product differentiation. As the previous studies, this paper discusses the spillovers related with production costs. However, for instance, FDI spillovers narrowing the quality difference between the products of the home and foreign firms is an interesting issue to be addressed.

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