Multinational firm and its operational choice: Inward and outward investment*

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Abstract

This paper studies how a multinational enterprise (MNE) coordinates the R&D investment and the foreign operational choice when it confronts with the budget constraint under the potential knowledge spillover. To explain the interrelation between MNE's R&D decision and operational choices, I focus on the two operational choices, FDI and the alliance, which are distinguished depending on whether it requires the MNE financial investment or not. The choices are further categorized into four, that is, a subsidiary, a joint venture, licensing, and cross-licensing. In a simple model, it is shown that the controllability of negative spillover is the most important factor for MNE's operational and R&D decisions. When the firms engage in the cooperative activities, it is shown that the host government can attract the greater amount of the MNE's technology if it puts more weight on R&D policy than FDI policy.

Keywords: *multinational enterprise, investment portfolio, R&D, spillover, FDI, subsidiary, joint venture, alliance, licensing, cross-licensing*

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1. Introduction

Cross-border trade is said prevalent in countries that locate close to the production location of a multinational enterprise (hence force, MNE). In addition to location advantage, there are many factors that affect MNEs' foreign operational choices.[1] The operational choice of a MNE will be affected not only by the accessibility to the foreign markets and the readiness of the foreign country's social and economic infrastructure but also by firm's internal resource allocation issue. For example, if a MNE is under budget constraint and intends to invest directly to the foreign market (FDI), it must allocate limited resource among inward and outward investments, that is, R&D investment and FDI, respectively. The former contributes to improve market competitiveness and the latter to increase profit opportunity. Then, how a MNE coordinates R&D investment and foreign operational choice when it confronts with budget constraint?

When trade barriers are very high, MNEs may seek other way to access foreign markets through FDI and / or concluding alliance contracts rather than choosing exports. For example, Dei (1990), Motta (1992) and Buckely and Casson (1998) show that high trade costs encourage FDI in the choice between export and FDI. Lankes and Venables (1996) study that the market size of the host country is a driving force for FDI. Those mentioned focus on FDI, that is, the way to obtain control right of a local firm. Now a days, however, we see many cases in which horizontally competitive MNEs form technological alliance. Since it takes time and efforts to effectively manage a new organization set up under FDI, firms rather form alliance in order to avoid managerial and pecuniary costs. Based on the limited knowledge of the author, however, few literature explains why a MNE chooses alliance instead of investing directly to a foreign market. Above are the issues concerned on firm's operational choice. On the other hand, a MNE must procure investment money for R&D under the budget constraint. This means that the behavior of a MNE can be correctly understood when both investment portfolio and operational choices are discussed simultaneously under the potential knowledge spillovers. Meanwhile, such firm's behavioral issues are the most familiar topics of the management theory and little attention has been paid in the economic theory until recently. Among few exceptions, Wong (1995) explains how the allocation of MNE's firm-specific management resource affects MNE's FDI revenue under the given R&D level. Ethier and Markusen (1996) discuss the effect of a given level of R&D investment on MNE's operational choice between exporting, licensing and FDI. Petit and Sanna-Randaccio (2000) develop the first international duopoly model, in which both firms' operational choice, export and FDI, and R&D level are endogenously determined. But they do not take the

[1] In OLI theory, Dunning (1993) explains that a MNE invests directly to the host country and manages a local firm when (i) it owns firm specific resources like technology and management know-how, Ownership-specific advantage, (ii) it can procure abundant and cheep production factors in the host country, Location-specific advantage, and (iii) it can save transaction costs by integrating local firm vertically, Internalization advantage.

R&D location into account. Kasuga (2003) focuses on ownership structure of a MNE and shows that the type of FDI, subsidiary and joint venture, is affected by the capital market imperfection. But he does not take the level of R&D into account.

I attempt to unify the MNE's decision making issues among R&D investment and operational choice for foreign activities. The motivation of this paper is close to Petit and Sanna-Randaccio (2000), however, what discriminate between this study and them as well as other previous literature is that I deal with the possibility of the technological alliance, the third option following to exports and FDI, when a technologically motivated MNE confronts with the budget constraint under the threat of knowledge spillovers. In this paper, I take up four operational choices, that is, a subsidiary, a joint venture, licensing and cross-licensing based on the assumption that the first two requires the MNE to invest in acquiring control right of an local firm but the rest does not. I call the former FDI and the latter *the alliance.* Note that cross-licensing is the way of technology exchange mechanism. In contrast to R&D cartel like joint venture, firms under a cross-licensing contract can independently invest in R&D and thus they are able to restrict part of the spillover.[2]In the conventional discussions of research joint venture, it is explained that firms form coalition to internalize the spillover cost. And yet, in reality, the cases of cross-licensing and *patent pool* are increasing in great number.[3] For example, in a cross-licensing contract, firms conduct R&D independently, and they can save time and money in the development of a new technology through diffusing and exchanging technologies under the potential threat of negative spillovers. There are costs and benefits in the cooperative activities, and that firms are motivated to exchange technology as far as the positive effects may exceed the negative ones. Furthermore, since MNE's operational choice is affected by whether the MNE aims at short-run or long-run profit, the difference in their profit chances are explicitly reflected in the term structure of each regime.

The main findings are the following: (i)The negative knowledge spillovers play the important role for the determination of MNE's strategies. (ii)Comparing the optimal levels of R&D investment in FDI, the levels is higher for the subsidiary option than for the joint venture for any holding-share rate even if negative spillover is negligible. (iii)For the alliance contract, the host government which intends to attract greater amount of the MNE's technologies had better improve the nation's absorptive capability. Comparing the MNE's total profits among four regimes, I shown that (iv) the MNE may prefer the subsidiary option to other three. Furthermore, licensing and cross-licensing may be better than joint venture. Because, the MNE can not control knowledge drain in the joint venture but the MNE may be possible to control it by adjusting the

2 In reality, horizontally competitive firms often form R&D cartel. See, for example, d'Aspremont and Jacquemin (1988) and Suzumura (1992), who show that the bigger the spillover rate, the stronger the firms' motivations for forming research cartel in the homogeneous-goods oligopoly models.

3 A patent pool is a consortium of at least two companies agreeing to cross-license patents, which are often licensed to the third party. The creation of a patent pool can save time and money of the vested interests, but the larger patent pool may distort market competition.

rate of technology transfer under the alliance. For the cooperative activities, it is the controllability of the knowledge spillovers that affects the operational choice of the MNE. These implications suggest that the host country who intends to attract foreign higher technology had better put more weight on R&D than FDI policies.

This paper is organized as follows. Section 2 describes the behavior of a MNE, in which the relation between investment portfolio and operational choices are explained. Particularly, operational choices are classified into four regimes; subsidiary, joint venture, licensing, and cross-licensing. In Section 3, I first derive the optimal decision in the above four regimes. Next I compare the results and the payoff among regimes. Section 4 concludes.

2. Behavior of a MNE: Investment portfolio and operational choice

Like any other firm, a MNE may have financial constraint so that it must allocate the resource based on its portfolio. In this paper, it is assumed that the *investment portfolio* of the MNE consists of the inward competitiveness investment and the outward foreign expansion investment, that is, R&D investment and FDI, respectively. If the MNE puts more weight on R&D investment, the investment money left for FDI is reduced if the financing from the third party is not allowed. The trade-off for the increase in market competitiveness is some loss of the profit chance from the foreign activities. However, there are other operational choices. For example, exports, licensing, and cross-licensing are the potential choices as far as they do not require a firm direct financial investment in to the host country. When the market risk and uncertainty incur profit loss for FDI, the outward investment failure directly affects financial position of MNE but not so hard when MNE chooses the one which does not need financial investment. Thus, the MNE's foreign expansion mode directly affects on the level of R&D investment, or vice versa. For the MNE's *operational choices*, I distinguish FDI from the *alliance*. The former is defined as the choice that requires monetary investment to acquire control right of a local firm, but the latter does not aim to do so. I further classify each of FDI and the alliance into two regimes as the following.

FDI: a subsidiary and a joint venture

In this paper, it is assumed that the MNE acquires θ100%share of a local firm, $\theta \in (0, 1]$.[4] I call the foreign affiliate a *subsidiary* if θ=1 and a *joint venture* if $1>\theta>0$. The newly acquired firm produces only in the host market and it takes time for the affiliate to go into operation. While R&D for the subsidiary is undertaken in the home country of the MNE, for the joint venture which is conducted in the host country. In contrast to a subsidiary, I assume that there is a negative

[4] The way to acquire control right of an organization, e.g., through green field investment, Merger and Acquisition, and other bargaining measures, is not the concern of this paper.

knowledge spillover for a joint venture.

Alliance: licensing and cross-licensing

The MNE (the licenser) must decide how much of its technology is transferred to a local partner (the licensee) and which type of the alliance contract to choose, that is, *licensing* or *cross-licensing*, simultaneously.[5] For a licensing contract, I suppose that the MNE can make profit immediately once it transfers technology. Though the technology of the MNE may spill over to the licensee, it is assumed that MNE can halt the spillover by spending observation cost. On the other hand, for a cross-licensing contract, the firms first exchange the technologies, which are developed independently, then they make use of partner's technology for the production. So, it takes time for the firms to make profits from this contract.

Fig.1 Investment portfolio and operational choices of the MNE:
The flow of the money and the R&D output.

In this paper, particular interests are shed light on trade-off between negative and positive spillover effects and the duration of MNE's projects, the profit chances. If the MNE intends to avoid knowledge spillover, the negative effect, it may prefer subsidiary option to joint venture, licensing and cross-licensing. However, if the possible licensing technologies are complementary, firms can exert larger positive spillover effect relative to negative effect, so that the cross-licensing contract may increase firms' profitability. On the other hand, if it takes time to prove FDI be effective, licensing is preferable for a myopic MNE who looks for the immediate profit. The relation between operational choices and profit chances reflected in MNE's profit structures are summarized in Table1.

Table.1 Profit chances of cross border activities.[6]

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5 This type of alliance is different from consignment sales, which can be a special case of exports when handling charges paid for a local partner / distributor is considered as an additional trade cost.

6 Under any choice, the MNE can earn production profits both in the first and the second periods in the home market. This is explained in Section 3.

3. The model

3.1 Decision making process of a MNE

There is one MNE in the home country, which intends to expand its economic activity in the foreign market, and one foreign local firm produce homogeneous goods in each country. I assume that the foreign firm is the potential production or R&D partner for the MNE but it can not expand its activity beyond the border.

The MNE conducts R&D activity in the home country, however, it produces in the home country as well as in the foreign country when it acquires a local firm through FDI. I assume that there is no risk in the home market but there are some in the foreign market, so that the MNE can avoid part of such risk by making alliance contract with the local partner. For the simplicity, asymmetric information inside the firm or between the firms is assumed away.

Next I explain the time structure of the model. There are two consecutive short periods, the first and the second period. So, the short term means one period, and the long term two periods, in which discount factor is assumed zero. Firms can produce in each period, and production is completed at each period. Firms' R&D activities, however, will be conducted once at the beginning of the first period and their results appear immediately before the first period production starts. At the beginning of the first period, the budget constrained MNE decides investment portfolio as well as foreign operational choice, simultaneously. As the financing from the third party is assumed away, MNE's resource allocation restricts its operational choice. If the MNE decides to invest in both R&D and FDI, it then decides how much to invest in R&D and in FDI. Under FDI, it takes time until the profit from the foreign affiliate is realized in the second period, therefore it is the long term project. On the other hand, if it invests only in R&D, its operational choice becomes the alliance so that it must decide the type of technology transfer. I assume that for the licensing, the MNE can transfer its technology immediately and consequently the MNE receives profit in two periods. In case of cross-licensing, the contract is short term and the MNE receives profit only in the second period. Because, the MNE and the local firm invest in R&D independently in the first period and exchange the technology at the beginning of the second period, which is used for next period production. These are again summarized as:

t=1: Given host country's trade policies, the MNE decides investment portfolio and operational choice simultaneously, at the beginning of the first period. Once the MNE invests in R&D, the results appear immediately and are used for the domestic production. If FDI is chosen, the MNE allocates the financial resource between R&D and FDI, and constructs a subsidiary or a joint venture, the foreign affiliate. Based on the assumption, FDI is a long term project, so that the affiliate can not produce goods until next period. If the alliance is chosen, the MNE invests all the financial resource into R&D. Under licensing contract, the MNE earns profit in each period, but no profit is earned in this period when cross-licensing is chosen.

t=2: For the case of FDI, the MNE's affiliate starts production. Note that there is no spillover under a subsidiary, but negative spillover appears when a joint venture is chosen. For the alliance, either contract brings profit at the end of this period, however, positive and negative spillover effects are appeared when cross-licensing is chosen.

Note that the MNE earns profits in each period which consists of two parts, one from the domestic market and the other from the foreign market.

Finally I explain the investment portfolio. Since the main concern of this paper is to analyze the behavior of a MNE, the decision making process of the MNE is focused in the following. Let K_0 be the MNE's initial financial asset, which is allocated for R&D investment K and for FDI investment K^* unless it does not invest abroad at all :

$$K_0 \geq K + K^* \quad (1)$$

where the asterisks express foreign country and K^* is evaluated by the unit exchange rate. I suppose there is no uncertainty in R&D investment, which produces positive *lump sum investment results* at one time. These results are used in the production by the investors without additional cost nor congestion like other quasi-public goods. This type of R&D products can be understood as the case of the brand.[7] Let k be MNE's R&D effort and $x=x(k)$ is the effective R&D output function, which is characterized as $x'(k)>0$, $x''(k)<0$, $x(0)=\underline{x}$ and $x^H \geq x(k) > \underline{x}$. x^H is the MNE's highest R&D performance and $\underline{x}>0$ is the MNE's initial R&D level. The R&D cost increases in the R&D effort and is presumed quadratic as $K=\frac{k^2}{2}$. I then define the R&D's positive externality on the production, that is, the *brand's power*, as

$$Rx(k) \quad (2)$$

where R is firm's net sales revenue calculated by subtracting the production cost from the sales revenue.

3.2 Foreign Direct Investment

7 The noted characteristics of the brand are: (i) because of non-rivalry characteristic, the number of users is not limited, and (ii) under proper maintenance effort, it is not obsolete so that the brand holder can use it in the long run.

For FDI, there are two choices, a subsidiary and a joint venture. First the MNE decides which type of the affiliate to construct. That is, the optimal level of R&D and FDI are decided simultaneously under the financial constraint (1). The MNE carries out R&D and invest in FDI project in the first period. Because of the characteristics of quasi-public goods, transfer cost of the firm specific technology from the MNE to the foreign affiliate is assumed zero. The profit of the foreign affiliate is realized in the second period using the MNE's first period R&D output. From assumption, there is a market risk for the FDI, the profit of the affiliate is given as $\pi_2^{*F} = (x(k), K^*; e^*, R_2^*, x^*(k^*))$ where the number of the subscripts express the period t, t=1 and 2, the superscripts F mean the variables relate to FDI, e^* is a random variable expressing the foreign market's uncertainty with the mean μ and the variance σ^2, $e^* \sim N(\mu, \sigma^2)$, R_2^* is the affiliate's second period net sales revenue, and $x^*(k^*)$ is the local partner's technology for the case of a joint venture. Moreover, since the MNE may be suffered from negative spillover for $x(k)$ and that the expected net dividend brought by the foreign affiliate becomes

$$\pi_2^{*i} = E[\theta \pi_2^{*F} - s^* x(k)] \qquad (3)$$

where the superscripts i=S and JV mean the variables relate to the regime under subsidiary and joint venture, E denotes the mathematical expectations operator, $s^* \in [0, 1]$ is the spillover rate.[8] That is, $s^*=0$ means no negative spillover, and for $s^*=1$ the technology is perfectly stolen. Under FDI, the profits in each period of the MNE are summarized as:

t=1: Profit in the home country ; $\pi_1 = R_1 x(k) - K$
t=2: Profit in the home country ; $\pi_2 = R_2 x(k)$
Net expected dividend from the foreign affiliate; π_2^{*i}

Subsidiary

First I illustrate the profit earned from the subsidy. From assumption, negative R&D spillover effect does note exist in the subsidiary option and that $s^*=0$. From (3) with θ=1, and the profit of the subsidiary is calculated as $\pi_2^{*F} = R_2^* x(k) - K^* - e^*$, the net expected dividend from the subsidiary is

$$\pi_2^{*S} = R_2^* x(k) - K^* \qquad (4)$$

8 I assume that firms are risk neutral for simplification of the discussion.

where the superscripts S express the subsidiary option. R&D output contributes to increase the domestic net revenue in two periods, I assume that each sales revenue be equal, i.e., $R=R_1=R_2$. Then, from (4), the MNE's expected total profit brought by choosing the subsidiary option is

$$\Pi^S=\pi_1+\pi_2+\pi_2^{*S}=(2R+R_2^*)x(k)-K-K^*. \qquad (5)$$

On the other hand, the participation constraint of the MNE for this project is

$$\pi_2^{*S}\geq 0. \qquad \text{(PC-S)}$$

From (1), (5) and (PC-S), the MNE's constrained optimization problem for choosing the subsidiary option becomes max Π^S s.t. $K_0\geq K+K^*$ and $\pi_2^{*S}\geq 0$. Then, the Lagrangean function can be written as

$$L^S=[(2R+R_2^*)x(k)-\frac{k^2}{2}-K^*]+\lambda[K_0-\frac{k^2}{2}-K^*]+\gamma[R_2^*x(k)-K_0+\frac{k^2}{2}] \qquad (6)$$

where $\lambda>0$ represents shadow price of the financial asset, $\gamma>0$ shadow value of increasing an extra revenue of the subsidiary, and $(1+\lambda-\gamma)>0$ is assumed. The first-order conditions corresponding to this optimization problem are

$$\frac{\partial L^S}{\partial k}=(2R+(1+\gamma)R_2^*)x'(k)-(1+\lambda-\gamma)k=0 \qquad (7\text{-}1)$$

$$\frac{\partial L^S}{\partial \lambda}=K_0-\frac{k^2}{2}-K^*=0 \qquad (7\text{-}2)$$

$$\frac{\partial L^S}{\partial \gamma}=R_2^*x(k)-K_0+\frac{k^2}{2}=0. \qquad (7\text{-}3)$$

Assuming interior solution and solving (7-1) for k, the optimal R&D level k^S satisfies

$$k^S=\frac{x'(k^S)(2R+(1+\gamma)R_2^*)}{1+\lambda-\gamma}, \qquad (8)$$

in which $\frac{\partial k^S}{\partial R}>0$, $\frac{\partial k^S}{\partial R_2^*}>0$, $\frac{\partial k^S}{\partial \lambda}<0$ and $\frac{\partial k^S}{\partial \gamma}>0$.[9] When the profitability of the markets increases, the

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[9] From implicit theorem,, we have $\frac{\partial k^S}{\partial R}=-\frac{2x'}{f}>0$, $\frac{\partial k^S}{\partial R_2^*}=-\frac{(1+\gamma)x'}{f}>0$, $\frac{\partial k^S}{\partial \lambda}=\frac{k}{f}<0$, and $\frac{\partial k^S}{\partial \gamma}=-\frac{R_2^*x'+k}{f}>0$ where $f=(2R+(1+\gamma)R_2^*)x''-(1+\lambda-\gamma)<0$.

MNE increases R&D. With the increase in shadow price of the capital, the MNE decreases R&D investment, but the increase in shadow marginal value of the subsidiary's revenue promotes the MNE to put more weight on R&D investment than FDI. That is, since the MNE does not suffer from negative spillover in the subsidiary option, the MNE prefers to receive greater positive spillover from R&D. These are summarized as:

Lemma1: Under the subsidiary option, the MNE's optimal level of R&D satisfies $k^S = \frac{x'(k^S)(2R+(1+\gamma)R_2^*)}{1+\lambda-\gamma}$*, which gives the optimal FDI investment level* $K^{*S}=K_0-\frac{k^{S2}}{2}$*. Since the MNE does not suffer from negative spillover in the subsidiary option, the MNE prefers to put more weight on R&D than FDI when the shadow marginal value of the subsidiary's revenue increases.*

Joint venture

If the MNE and the local investor agree to jointly hold a joint venture, they invest in it at the beginning of the first period. The holding share of the MNE is $6$100%. The investment money necessarily for MNE in the joint venture is $6K^*$, therefore the MNE's budget constraint becomes

$$K_0 \geq K + 6K^*. \tag{9}$$

Since it takes time to put the joint venture into work, they conduct R&D jointly at the beginning of the second period injecting owners' R&D output realized in the first period. Thus the profit of the joint venture is earned at the end of the second period in the host country. The way they manage the joint venture is to combine their technologies, so I define the cooperative R&D output be

$$\frac{x(k)+x^*(k^*)}{2} \tag{10}$$

where $x^*(k^*)$ is the R&D output of the local investor. Then the knowledge spillover cost in (3) becomes $s^*\frac{x(k)}{2}>0$ with $1 \geq s^* > 0$. The profit of the joint venture is $\pi_2^{*F} = R_2^*(\frac{x(k)+x^*(k^*)}{2}) - K^* - e^*$ where the project scale K^* is expressed in terms of the MNE's asset. So the MNE's net expected dividend from the joint venture π_2^{*JV} is calculated as

$$\pi_2^{*JV} = 6(R_2^* \frac{x(k)+x^*(k^*)}{2} - K^*) - s^* \frac{x(k)}{2}. \tag{11}$$

The total profit of the MNE becomes

$$\Pi^{JV}=\pi_1+\pi_2+\pi_2^{*JV}=2Rx(k)+\theta R_2^*\frac{x(k)+x^*(k^*)}{2}-K-\theta K^*-s^*\frac{x(k)}{2} \tag{12}$$

where $\theta R_2^*-s^*>0$ is assumed and the superscripts *JV* express the joint venture option. The participation constraint (PC-JV) for the MNE is

$$\pi_2^{*JV}\geq 0. \tag{PC-JV}$$

From (9), (12), and (PC-JV), the Lagrangean of the MNE for choosing the joint venture can be written as

$$L^{JV}=[2Rx(k)+\theta R_2^*\frac{x(k)+x^*(k^*)}{2}-K-\theta K^*-s^*\frac{x(k)}{2}]+\lambda[K_0-\frac{k^2}{2}-\theta K^*]$$
$$+\gamma[\theta(R_2^*\frac{x(k)+x^*(k^*)}{2}-K^*)-s^*\frac{x(k)}{2}] \tag{13}$$

where $\lambda,\ \gamma>0$. The first-order conditions corresponding to this optimization problem are

$$\frac{\partial L^{JV}}{\partial k}=[2R+\frac{(1+\gamma)(\theta R_2^*-s^*)}{2}]x'(k)-(1+\lambda-\gamma)k=0 \tag{14-1}$$
$$\frac{\partial L^{JV}}{\partial \lambda}=K_0-\frac{k^2}{2}-\theta K^*=0 \tag{14-2}$$
$$\frac{\partial L^{JV}}{\partial \gamma}=\theta(R_2^*\frac{x(k)+x^*(k^*)}{2}-K^*)-s^*\frac{x(k)}{2}=0 \tag{14-3}$$

Assuming the interior solution and solving (14-1) for *k*, the optimal R&D level k^{JV} satisfies

$$k^{JV}=\frac{x'(k^{JV})(4R+(1+\gamma)(\theta R_2^*-s^*))}{2(1+\lambda-\gamma)}\geq 0, \tag{15}$$

which also gives the optimal level of FDI investment $\theta K^{*JV}=K_0-\frac{k^{JV\,2}}{2}$. Note that $k^{JV}=0$ if $\theta R_2^*<s^*$. Then, we have $\frac{\partial k^{JV}}{\partial R}>0$, $\frac{\partial k^{JV}}{\partial R_2^*}>0$, $\frac{\partial k^{JV}}{\partial \lambda}<0$, $\frac{\partial k^{JV}}{\partial \gamma}>0$, $\frac{\partial k^{JV}}{\partial \theta}>0$ and $\frac{\partial k^{JV}}{\partial s^*}<0$.[10] Note that the characteristics are the same to those of the subsidiary option except for the positive impact on the

10 From implicit theorem, we have $\frac{\partial k^{JV}}{\partial R}=-\frac{2x'}{g}>0$, $\frac{\partial k^{JV}}{\partial R_2^*}=-\frac{(1+\gamma)x'\theta}{2g}>0$, $\frac{\partial k^{JV}}{\partial \lambda}=\frac{k}{g}<0$, $\frac{\partial k^{JV}}{\partial \gamma}=-\frac{2k+(\theta R_2^*-s^*)}{2g}>0$, $\frac{\partial k^{JV}}{\partial \theta}=-\frac{(1+\gamma)R_2^*x'}{2g}>0$ and $\frac{\partial k^{JV}}{\partial s^*}=\frac{(1+\gamma)x'}{2g}<0$ where $g=[2R+(1+\gamma)\frac{\theta R_2^*-s^*}{2}]x''-(1+\lambda-\gamma)<0$.

optimal R&D level brought by the marginal increase in holding share and the negative impact by spillover rate in the host country. So, if the host government intends to attract MNE's higher technology, it is more effective to promote inward financial investment than to strengthen intellectual property right.

Lemma. 2 Under the joint venture option, the MNE decides the optimal level of R&D so as to satisfy $k^{JV}=\dfrac{x'(k^{JV})(4R+(1+\gamma)(\theta R_2^*-s^*))}{2(1+\lambda-\gamma)}\geq 0$. *The MNE may not invest in R&D at all if spillover rate is quite high. To attract MNE's higher level of R&D, it is the policies that the host government to introduce to promote direct inward investment not to strengthen intellectual property right.*

3.3 The Alliance

For the alliance, there are two choices, licensing and cross-licensing. If the MNE does not choose FDI, it may conclude an alliance contract with the local firm. Note that the MNE can avert direct market risk, $e^*=0$, however, there are negative and positive externality in the alliance. From assumption, alliance formation does not need financial investment so that the MNE must decide how much of its technology or brands be transferred. Since it invests all the financial resource into R&D, that is, $K^*=0$, the level of MNE's R&D output is the highest in the alliance when the budget constraint is satisfied with equal:

$$x^H=x(\sqrt{2K_0}). \qquad (16)$$

Licensing

Licensing is carried out by selling part of MNE's technology developed at the beginning of the first period to the local firm, the licensee.[11] If the both parties agree to sing the contract, in which re-negotiation about the contract is not permitted, the term of licensing contract is assumed valid for two periods so that the licensee can use this technology for the production in two periods. Then the MNE can receive royalty in two consecutive periods. Let MNE's technology transfer rate be $\tau^L\in[0, 1]$, the MNE will transfer

$$x^L=\tau^L x^H \qquad (17)$$

where the superscripts *L* express variables under licensing. Let $w>0$ be per unit royalty fee, then

[11] This type of alliance is similar to consignment sales, which can be a special case of exports as far as handling charges paid for a local partner / distributor are considered additional trade costs.

the MNE's revenue from licensing becomes $R_t^* w x^L$, t=1, 2. On the other hand, the MNE must pay *monitoring cost* not to allow technology spillover to the licensee, which is increasing in the volume of transferred R&D output. This cost depends on the preparedness of the infrastructure in the host country, the degree of which is expressed by $s^{*L}>0$.[12] The monitoring cost for the MNE is defined as

$$C^L = \frac{s^{*L}(x^L)^2}{2} \tag{18}$$

where $\partial C^L/\partial \tau^L>0$, $\partial^2 C^L/\partial \tau^{L\,2}>0$, $\partial C^L/\partial s^{*L}>0$, $\partial^2 C^L/\partial s^{*L}\partial \tau^L>0$. The increase in the transfer rate pushes MNE's monitoring cost, the upgrade of the host country's infrastructure reduces it, and the increase in technology transfer in accordance with the improvement in infrastructure increases it.

Under licensing, the MNE's profits in the home market are $\pi_1^L=(R_1 x^H - K_0)$ and $\pi_2^L=(R_2 x^H)$, and the net royalty revenue are $\pi_1^{*L}=R_1^* w x^L - C^L$ and $\pi_2^{*L}=R_2^* w x^L - C^L$. Assuming $R=R_1=R_2$ and $R^*=R_1^*=R_2^*$, then the total profit of the MNE becomes

$$\Pi^L=[\pi_1^L+\pi_1^{*L}]+[\pi_2^L+\pi_2^{*L}]=2x^H\left(R+R^* w \tau^L - \frac{s^{*L}(\tau^L x^H)^2}{2}\right)-K_0. \tag{19}$$

Differentiating (19) in terms of τ and solving it for the optimal transfer rate, we have

$$\tau^L = \frac{R^* w}{s^{*L}(x^H)^2} > 0 \tag{20}$$

where $\partial \tau^L/\partial s^{*L}<0$, $\partial \tau^L/\partial x^H<0$, $\partial \tau^L/\partial R^*>0$, and $\partial \tau^L/\partial w>0$. The higher technology will be transferred if the more the host government improves its infrastructure and promotes the profitability of the foreign licensee, the more the MNE increases transfer rate. But, the more the R&D is hard to develop, the fewer it transfers technology.

Lemma 3. Under licensing contract, the MNE's optimal technology transfer rate is $\tau^L=\frac{R^* w}{s^{*L}(x^H)^2}>0$. *The host government can attract higher technology by improving its infrastructure and firms' profitability in the country. But, the more the MNE's technology is precious, the fewer the MNE may transfer it.*

Cross-licensing

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12 The greater value means inferior infrastructure, it is the case when the intellectual property rights are not fully protected. The cost may also depend on the technological absorption capability of the licensee, which is explicitly discussed in the cross-licensing contract.

The MNE and the local firm execute R&D activities at the beginning of the first period, and they exchange R&D output at the end of that period. It does not require the technology level of the local firm is inferior to that of the MNE.[13] If anything, it is presumed that the local firm must spend considerable costs and efforts to make full use of MNE's technologies. The cross-licensed technologies are utilized in the second period production. Note that R&D and productions are conducted independently at any period of the time. So, the MNE, as well as the local firm, must decide technology transfer rate $\tau^{C}\in[0, 1]$ at the beginning of the first period, in which the superscripts *C* express variables under cross-licensing. The amount of the MNE's R&D transfer is

$$x^{C}=\tau^{C}x^{H}. \tag{21}$$

The MNE can perfectly make use of transferred technology without cost, and it receives direct trading merit x^*, which is the R&D output transferred from the local partner, in return for x^{C}. So that $x^*=x^{C}$ holds. On the contrary, it is assumed that it is costly for the local firm to make use of MNE's transferred technology. Let the technological *absorption capability* of the local firm is reflected on $s^{*C}\in(0, 1)$, then the effective amount of R&D output received by the local firm be $s^{*C}x^{C}$. The output of the applied technology A^* of the local firm expresses diminishing return to the MNE's transferred technology. More specifically

$$A^*=2(s^{*C}x^{C})^{\frac{1}{2}} \tag{22}$$

is assumed where $\partial A^*/\partial\tau^{C}>0$, $\partial^2 A^*/\partial\tau^{C\,2}<0$, $\partial A^*/\partial s^{*C}>0$, $\partial A^*/\partial s^{*C2}<0$, $\partial^2 A^*/\partial s^{*C}\partial\tau^{C}>0$. Accordingly, the MNE's negative spillover is the function of A^*.

The firms devote themselves into independent R&D activities at the beginning of the first period, and they use their own R&D output for the production in each market. Then in the second period, they exchange technologies which are made use for the second period productions. The MNE's first period profit is $\pi_1^C=\pi_1^L=R_1x^{H}-K_0$ and that in the second period π_2^C becomes

$$\pi_2^C=R_2(x^{H}+x^*)-R_2^*A^* \tag{23}$$

where $x^*=x^{C}$.[14] From (23) under the assumption of $R=R_1=R_2$, the total profit of the MNE is

13 Even if the R&D output level of the local firm is lower than that of the MNE, MNE can absorb important market specific characteristics through collaborative activities. Because, under cross-licensing, the MNE can strengthen its relationship with the local partner in the hope that its technologies will be more used in a newly developed products in the host market. The relationship also enables the MNE to catch a glimpse of technology and market trends in the host country.

14 The profit of the local firm in the second period is $\pi_2^{*C}=R_2^*x^*+R_2^*A-x^*$.

$$\Pi^{C}=\pi_1^C+\pi_2^C=Rx^{H}(2+\tau^{C})-2R_2^*(s^{*C}\tau^C x^H)^{\frac{1}{2}}-K_0. \tag{24}$$

Differentiating (24) in terms of τ^C and its first-order condition gives the optimal transfer rate

$$\tau^{C}=\frac{s^{*C}}{x^H}\left(\frac{R_2^*}{R}\right)^2>0. \tag{25}$$

where $\partial\tau^C/\partial s^{*C}>0$, $\partial\tau^C/\partial R_2^*>0$, $\partial\tau^C/\partial x^H<0$ and $\partial\tau^C/\partial R<0$. The more the host government improves nation's potential developing ability and the profitability of the local firm, the more the MNE increases transfer rate. On the other hand, the more the R&D is precious for the MNE, the fewer the technology is exchanged. And for the avoidance of negative technology spillovers, the MNE may reduce technology transfer when the profitability of the domestic market increases.

Lemma 4. Under cross-licensing contract, the MNE's optimal technology transfer rate is $\tau^{C}=\frac{s^{*C}}{x^H}\left(\frac{R_2^*}{R}\right)^2>0$. *The host government can attract the MNE's highest and greater technology if it could improve the profitability and the absorption capability of the licensee under the cross-licensing contract. But, the more the MNE's technology is precious and the more the home market be profitable, the fewer the technology of the MNE may be exchanged.*

3.4 Comparisons

I compare the equilibrium outcomes. First I compare the optimal R&D levels under choices between subsidiary and joint venture. For the calculation, define R&D output function as $x=2k^{1/2}$. Then from (8) and (15), we have

$$k^{S}>k^{JV}. \tag{26}$$ [15]

That is, even if negative spillover is negligible, $s^*\to 0$, the optimal R&D levels is higher for the subsidiary option than for the joint venture regardless of the rate of share-holding.

Then I compare the optimal technology transfer levels in the alliance under licensing and cross-licensing. From (20) and (25), we have

$$\tau^{L}-\tau^{C}=\frac{R_2^*(wR^2-s^{*C}s^{*L}R_2^*x^H)}{s^{*L}(Rx^H)^2}.$$

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15 See Appendix 1 for the proof.

(27)

The sign of $\tau^{L}-\tau^{C}$ depends on the sign of $wR^2 - s^{*C}s^{*L}R_2^* x^H$. If $R^2 \leq (s^{*C}s^{*L}R_2^* x^H)/w$ holds, then technology transfer rate is higher for cross-licensing than licensing, $\tau^{L}<\tau^{C}$.[16]

Lemma 5. When the budget constrained MNE chooses FDI, it prefers the subsidiary option to the joint venture even if technology spillover is negligible. On the other hand, when the alliance is chosen, the MNE may prefers cross-licensing to licensing if $wR^2 - s^{*C}s^{*L}R_2^* x^H < 0$.

Finally using numerical examples, I compare the MNE's equilibrium total profits in the four regimes, that is, Π^S, Π^{JV}, Π^L, and Π^C. For the computation, I set [$R=R^*=\gamma=\lambda=w=1$, $s^*=s^{*L}=s^{*C}=0.5$, $x^*(k^*)=1$, $K_0=2$]. The application of these examples to (8), (15), (20), and (25) gives $k^S=2.5198$, $k^{JV}=1.587$, $\tau^L=0.25$, $\tau^C=0.1767$ and $x^H=2.8284$, so that we have $x^H>k^S>k^{JV}$ and $\tau^L>\tau^C$. Substituting these optimal R&D levels and technology transfer rates for (5), (12), (19), and (24), we have the MNE's equilibrium total profits for each regimes: $\Pi^S=7.5244$, $\Pi^{JV}=0.7698$, $\Pi^L=5.8818$, and $\Pi^C=3.1568$. In sum, under the particular numerical examples, we can assert that:

Lemma 6. When the optimal technology transfer rate of licensing contract is higher than that of cross-licensing, the total profit of the MNE is the highest for the subsidiary option but the joint venture option is inferior to the alliance contracts, that is, $\Pi^S>\Pi^L>\Pi^C>\Pi^{JV}$ *with* $\tau^L>\tau^C$ *and* $x^H>k^S>k^{JV}$. *If the host government tries to encourage the MNE to set up a subsidiary or to promote alliance contracts, it can attract larger technology than that brought by joint venture.*

4. Conclusions

A firm is basically constrained to the budget so as the MNE's investment portfolio is affected by the allocation of the financial resource between inward and outward investments. When the MNE can introduce other expansion tools without investing directly to the host country, it is able to save the investment money for enhancing its technological competitiveness. It is the alliance contracts such as licensing and cross-licensing that may help the MNE to invest all the financial resource into R&D. I therefore introduce the alliance as the possible tools next to FDI for the constrained MNE when it must decide investment portfolio and foreign operational choice, simultaneously. In the model, I show that the controllability of the negative knowledge spillover can be the important determinant of MNE's strategy. It is also shown that the technological infrastructure of the host country is important to attract greater amount of the MNE's R&D output

16 See Appendix 2 for details.

when the MNE chooses the alliance. That is, from the view point of the host government who intends to attract higher foreign technology, it had better put more weight on R&D policies than FDI policies.

Since I focus on the internal decision making process of a MNE, firms' interactive and strategic behavior are not dealt with. For the endogenous determination of the choice between investment portfolio and operational choice, it is necessarily to reflect the market risk and the firms' risk preference explicitly. Furthermore, whether the goods and technologies are substitutable or complement must be considered for the proper understanding of firms' collaborative activities.

Appendix

1. From (8) and (15), we have $k^{S}-k^{JV}=\dfrac{2X^{1/3}-(2Y)^{1/3}}{2(1+\lambda-\gamma)^{2/3}}$, in which $X=(2R+(1+\gamma)R_2^*)^2$ and $Y=(-4R+(1+\gamma)(s^*-\theta R_2^*))^2$. Since $1+\lambda-\gamma>0$, $k^{S}-k^{JV}\leq 0$ holds if $2X^{1/3}-(2Y)^{1/3}\leq 0$, that is, $8R+(1+\gamma)R_2^*(1+\theta)-(1+\gamma)s^*\leq 0$. But since $(1+\gamma)R_2^*(1+\theta)>(1+\gamma)s^*$ holds, the last inequality does not hold. So that we have $2X^{1/3}-(2Y)^{1/3}>0$, which yields $k^{S}-k^{JV}>0$.

2. From (27), we have $\partial(\tau^{L}-\tau^{C})/\partial s^{*L}=-\dfrac{wR_2^*}{(s^{*L}x^{H})^2}<0$, $\partial^2(\tau^{L}-\tau^{C})/\partial s^{*L2}=\dfrac{2wR_2^*}{s^{*L3}x^{H2}}<0$, $\partial(\tau^{L}-\tau^{C})/\partial s^{*C}=-\dfrac{R_2^{*2}}{R^2x^{H}}<0$, $\partial^2(\tau^{L}-\tau^{C})/\partial s^{*C2}=0$, $\partial(\tau^{L}-\tau^{C})/\partial R_2^*=\dfrac{wR^2-2s^{*L}s^{*C}R_2^*x^{H}}{s^{*L}(Rx^{H})^2}$ and $\partial^2(\tau^{L}-\tau^{C})/\partial R_2^{*2}=-\dfrac{2R_2^*}{R^2x^{H}}<0$.

That is, there is a threshold value in s^{*C} at which the MNE's transfer rate of cross-licensing technology is larger than that of under licensing. When the potential ability of the host country is low, i.e., smaller s^{*C}, the MNE chooses licensing rather than cross-licensing contract, but this will be altered when the licensee becomes competitive in developing higher technology.

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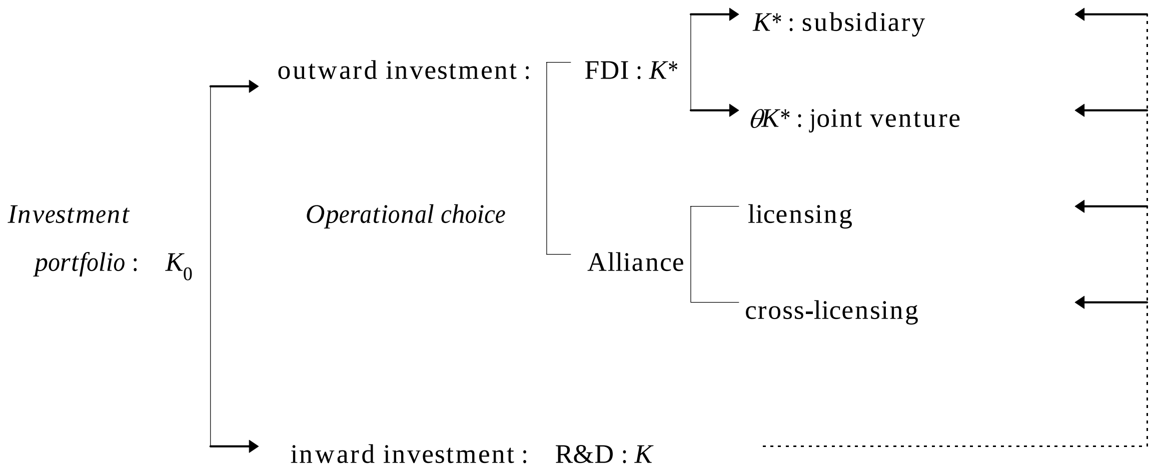

Fig.1 Investment portfolio and operational choices of the MNE:
The flow of the financial resource and the R&D output.

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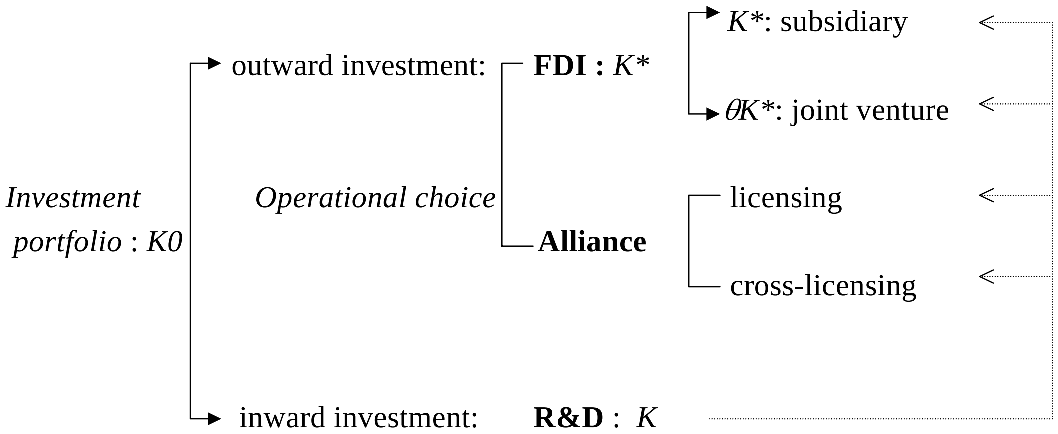

Operational choices		Profit from the foreign market
FDI	subsidiary	the second period (100% profit)
	joint venture	the second period (100θ% profit)
Alliance	licensing	the first and the second period (royalty revenue)
	cross-licensing	the second period (knowledge exchange benefit)

Table.1 Profit chances of cross border activities.