THE KOREAN ECONOMIC REVIEW
Volume 14, Number 2, Winter 1998

OPTIMAL TAXATION OF FDI IN A SMALL OPEN ECONOMY

SANGWHAN LHO*

Most previous stuides on optimal taxation of foreign direct investment income(FDI) have focused on optimal taxation of international capital flows. However, some studies have shown that multinationals exist not because of a capital abundance in a home country. Then, if foreign direct investment occurs due to some technological advantage over a host country, optimal taxation on FDI will be changed for both the host and the home country. Therefore, the study analyzes the optimal taxation on a multinational firms investment in intangibles. I assume R&D investment is a representative intangible. Unlike physical capital, R&D investment has the characteristics of being a public good.

JEL Classification: H21
Keywords: Optimal Taxation, FDI, R&D Spillovers

I. INTRODUCTION

Tax treatment of income originating from international investment is an important issue of economic policy to the capital-importing as well as to the capital-exporting countries of the world. [Kemp(1962), Hamada(1966), Feldstein and Hartman(1979), Horst(1980), Slemrod(1989), Razin and Sadka(1989), Pereira and Wang(1990) and Gordon(1986, 1992) etc.]. The studies have so far bypassed the taxation of the multinational's investment in intangibles. That is, the existing theory is an application of the theory of optimal taxation on international capital flows. However, various studies [Hufbauer(1975) and Caves(1982)] have shown that multinationals exist not because of a capital abundance in the home country but because they have some technological or managerial advantage over the host

Received for publication: Jan. 15, 1998. *Revision accepted:* May 29, 1998.

* Research Fellow, Korea Environment Institute, 1049-1, Sadang, Dongjak, Seoul 156-090, Korea. e-mail : shno@keins.kei.re.kr. I am very grateful to Professor Joel Slemrod at the University of Michigan and anonymous two referees for valuable discussion and suggestions. All remaining errors are absolutely mine.

country.

Huizinga(1991, 1992) examined the link between taxation and the multinational's investment in research and development of new products, which is an important typical intangible since the multinational firm may have some intangible or invisible assets such as a superior technology or management.

This paper examines the optimal taxation on foreign direct investment income in process-innovating multinational firm.[1] It, further, will research the optimal taxation on the case of the externalities or spillovers of multinational firm's research and development. Investing in research and development (R&D) leads to the development of new products and the introduction of new or modified production processes. A feature of R&D investment that distinguishes it from other firms of investment is that firms which do the investing are often not able to exclude others from freely obtaining the benefits from the R&D projects. Some firms benefit from R&D investment of other firms in the economy, although the recipient firms have not paid for the use of the knowledge generated by the R&D activity. There is some evidence of R&D spillovers or externalities [Griliches(1979, 1991), Spence(1984), Jaffe(1986, 1988), and Bernstein and Nadiri(1988, 1989, 1991) etc.]. They have analyzed the implications of both inter-industry and intra-industry R&D spillovers. However, another important issue is the realm of international R&D spillovers. Indeed, there is significant knowledge diffusion through spillovers between Japan and the U.S., between EEC and the U.S. and between EEC countries etc.

This chapter examines optimal taxation on foreign direct investment income in a process-innovating multinational firm in a small open economy. The next section revisits optimal taxation in the traditional model of a small economy. Section III demonstrates optimal taxation in foreign source investment income from process innovation. Section IV examines the optimal tax rate on FDI in the model of section III including R&D spillovers. Section V summarizes the derived results and discusses some more issues. Finally, section VI closes with some conclusions.

II. REVISITING OPTIMAL TAXATION IN THE TRADITIONAL MODEL OF A SMALL ECONOMY

This section presents the optimal taxation on foreign source investment income in the traditional model of a small open economy. That is, the theory is an application of optimal taxation on international capital flows. Under full taxation after deduction, the optimal tax rate on FDI in a small host country is zero, while, in a home country, the tax rate at home and abroad would be equal.[2]

[1] Process innovation reduces the producing cost of existing products, while product innovation creates new goods and services.

[2] The full taxation after deduction method is that the host country collects a tax on foreign

If, however, individuals in the home country can shift their savings abroad and escape any domestic tax, then no domestic taxes can be collected and the optimal domestic tax rate is in fact zero. Then, the optimal tax rate on FDI is also zero [Razin and Sadka(1989) and Gordon(1986, 1992)]. Yet, all countries do tax capital income domestically. This section shows again what the optimal tax rate on foreign direct investment income is, given a positive tax rate on domestic investment incom (second-best analysis). In this section, all international capital flows take the form of direct investment by internationals.

Suppose the production functions in the home country are $F^*(L^*, K^*)$ for a parent firm and $F^m(L^m, K^m)$ for a subsidiary and the production function in the host country which excludes a subsidiary firm's production function is $F(L, K)$, where L^*, L are the home and host country labor endowments and K^*, K are the home and host capital endowments, respectively. K^*, L are assumed to be fixed and equal to $(K^*+K^m), (L+L^m)$, respectively. Labor is assumed not to be mobile. It is also assumed that the production functions are constant returns to scale(CRS). Then, the multinational firm earns the sum of after-tax profits of the parent firm and of its subsidiary, that is $(1-t^*)[F^*(L^*, K^*)-w^*L^*]+[(1-t^{*^s})(1-t^s)+\Psi t^s][F^m(L^m, K^m)-wL^m]$ $-r^*(K^*+K^m)$. t^* is a tax rate on domestic investment income in the home country, t^{*^S} is a tax rate on foreign investment income in the home country, t^s is a tax rate on foreign investment income in the host country, Ψ is a tax credit for tax paid to the host country and r^* is a rate of retrun on capital in the home country. For simplicity, this analysis assumes that Ψ is zero, that means the tax system of the home country is full taxation after deduction.[3)4)]

In a small open economy, the net rate on return of capital inflow in the host country should be the world rate of return (but gross of the home country tax on FDI), $\bar{r}$. That is,

$$\bar{r}=(1-t^s)F_k^m \tag{1.a}$$

direct investment income and then, the home country levies a tax on net foreign source income.

[3] When the home tax system is full taxation after deduction, Ψ is zero. When the home tax system is tax credit system in a deficit tax credit position, Ψ is $(1-t^{*^s})$ and, when the home tax system is tax credit in an excess tax credit position or tax exemption, Ψ is $(1-t^s)t^{*^s}/t^s$.

[4] At present, the deduction system is not implemented by any country for foreign income taxes except in circumstances where a company so chooses. The reason for considering the deduction system is that it has often been regarded as the optimal tax when the objective is to maximize national social welfare (Masgrave(1972), Feldstein and Hartman(1979)). Most countries use 'tax credit' and 'tax exemption' to avoid double taxation. For example, the United States, the United Kingdom, Canada, Japan, Austria, Belgium, Denmark, Finland Germany, Greece, Ireland, Italy, Norway, Spain, Sweden, etc. use the crediting method while Australia, France, Netherlands and Switzerland etc. exempt the taxation on foreign source investment income.

The equilibrium of a multinational firm's investment requires that domestic and foreign investment be indifferent between investing in domestically located capital and capital located abroad. If considerations such as risk and nationalism are ignored, such indifference requires that each owner of capital earn the same after-tax rate of return on both foreign and domestic investments. The equilibrium is as follows:

$$(1-t^*)F_k^* = [(1-t^{*^s})(1-t^s)]F_k^m \tag{1.b}$$

If the above condition is not satisfied, the multinational firm has an incentive for movements of capital to maximize its own profits. In other words, if the left side of the equation (1.b) is greater (less) than the right side of the equations, the firm wants to invest less (more) capital in the subsidiary firm. Equation (1.a) and (1.b) are simultaneously satisfied if and only if

$$(1-t^*)F_k^* = (1-t^{*^s})\overline{r} \tag{2}$$

As the labor market equilibrium,

$$F_l(L, K) = F_l^m(L^m, K^m) \tag{3}$$

The equilibrium is that the host country firm pays a wage 'w' equal to the marginal product of labor, and host country workers are free to work for either the host country firm or the subsidiary firm. I assume that the demand for labor by the subsidiary firm is small enough to leave the host country wage 'w' unchanged.[5]

At a non-cooperative Nash equilibrium, countries choose their tax rates so as to maximize their social welfare, given a tax rate of the other country on FDI. The host country collects tax revenue on foreign direct investment income regardless of the home country taxation. That is, the host country chooses the tax rate on FDI to maximize its own social welfare (national income). The social welfare function for the host country is $F(L, K) + F^m(L^m, K^m) - (1-t^s)F_k^m K^m$. If $(dK^m/dt^s) \neq 0$, the first order condition (FOC) of host country is $r = F_k^m$.[6] The optimal tax rate on FDI in the host country is zero, based on the FOC of the host country social welfare function and the equilibrium (1.a). That is, the host country does not tax on foreign investment income to maximize its own social welfare. Next, the home country also maximizes its own social welfare function, $F^*(L^*, K^*) + (1-t^s)[F^m(L^m, K^m) - wL^m]$. The

---

[5] Feldstein and Hartman(1979) analyzed the large country case by dropping the assumption of the host country wage fixed.

[6] Substitute $r = (1-t^s)F_k^m$ into the host country social welfare function.

optimal tax rate on FDI in the home country is equal to the tax rate on domestic investment income, $t^{*^s}=t^*$ based on $F_k^*=(1-t^s)F_k^m$, $t^s=0$ and the equilibrium (2). The before-tax rates of return of both the parent firm and its subsidiary are the same as the world rate of return, $r=F_k^*=F_k^m$. The efficiency of worldwide capital allocation is satisfied. That is, foreign direct investment income should be equal to domestic investment income, which is not different from Feldstein and Hartman's results.[7]

Next, when the home country is a leader and the host country is a follower, the host country can take the home country tax rate as given, assuming that its choice of tax rate on FDI of the host country does not affect the home country tax rate. In contrast, the home country takes into account the effect of its choice of home country's tax rate upon the host country tax rate on FDI. Then, the host country tax policy is just same form as non-cooperative Nash equilibrium. The home country's behavior changes since (dt^s/dt^{*^s}) is no longer zero. The home country in not affected by the tax interdependence since the social welfare in the home country $(=F^*(\overline{L^*}, K^*)+\overline{r}K^m)$ is not a function of t^s. That is, the home country taxes on FDI is based on $t^{*^s}=t^*$.

Generally, the social welfare in the host country is affected by the tax rate on foreign source investment income in the home country, or the social welfare in the home country is affected by the tax rate on foreign investment income in the host country. Therefore, the optimal tax is determined by taking into consideration the effects of taxation of FDI on the social welfare of both the host and home countries rather than on each separate social welfare. Consider the Pareto-optimal tax rate on FDI, which is the optimal home country or the optimal host country tax rate on FDI without reducing the home or the host country's social welfare.

$$Max\ \ SW=F(L,\overline{K})+F^m(L^m, K^m)-(1-t^s)F_k^mK^m \qquad (4)$$
$$s.t\ \ \overline{SW}=F^*(\overline{L^*}, K^*)+(1-t^s)[F^m(L^m, K^m)-wL^m](=SW^*)$$

To find out tax rates on FDI in the above equation (4), form a Lagrangian, and maximize the host country's social welfare, given the home country's social welfare. A pareto optimum is found by finding (t^s, t^{*^s}) and λ such that the partial derivatives of the Lagrangian,

$$L=SW-\lambda(\overline{SW}-SW^*) \qquad (5)$$

where λ is a Largrangian parameter

with respect to t^s and t^{*^s} are both zero in the equation (5), that is, $\partial L/\partial t^s=0$

[7] In a Large open economy, they argue that foreign investment income should be treated less favorably than domestic investment income.

and $\partial L/\partial t^{*^s}=0$. The host country tax rate at Pareto-optimal $(\alpha^s = t^s/(1-t^s))$, is $\lambda\,\varepsilon_k(t^* - t^{*^s})/(1-t^*)(\varepsilon_k - 1 + \lambda)$ where $\varepsilon_k = -(dK^m/dt^s)(t^s/K^m)$ and the home country tax rate is $t^* - \alpha^s(1-t^*)/\lambda$. Based on the two tax rates, the host country tax rate at Pareto-optimal is zero and the home country tax rate is t^* (see Figure 1). That is, the Pareto-optimal tax rate is exactly the same as the Nash equilibrium tax rate.

In summary, the tax rates on FDI are zero for the host country and t^* for the home country regardless of strategic aspects (Nash, Stackelberg equilibrium and Pareto-optimal). The following describes how the host or home country levies taxes on foreign direct investment income when multinationals have some technological or managerial advantage over host country.

Ⅲ. THE OPTIMAL TAXATION IN THE PROCESS-INNOVATING MODEL WITHOUT R&D SPILLOVERS

This section maintains all the framework and assumptions of section II except that the capital of the multinational firm has characteristics of public good.[8] Various studies have shown that multinationals exist not because of a capital abundance in the home country but because they have some technological or managerial advantage over host country. Therefore, the home country can restrict or expand the amount of R&D by adjusting its own tax rate on FDI. Aggregate production of the host country which excludes a subidiary firm's production function is determined by a production technology $F=F(L)$ where L is $(L-L^m)$ (Note: L is employed by the host country firm and L^m is employed by the subsidiary firm). Aggregate production of the parent firm and its subsidiary are $F^* = F^*(X,\ L^*)$ and $F^m = F^m(X,\ L^m)$, respectively, where X is the amount of R&D. The amount of R&D has characteristics of public good between the parent firm and its subsidiary; that is, the R&D investment by the multinational firm enhances the multinational's productivity and profitability everywhere the multinational operates.[9] However, there is no royalty payment and transfer pricing between the parent firm and its subsidiary[10] and the host country firm does not receive any benefits from the multinational firm's R&D. In other words, there are no spillover effects.[11] The cost function of R&D is $C(X)$.

[8] The characteristics of public good are non-rivalry and non-excludibility.

[9] However, Hines(1993) considered three types of R&D, that is, R&D performed domestically for use in the U.S., R&D performed abroad for use in the US, and R&D performed both domestically and abroad for use in the US. It is an artificial approach since the technology is unlikely to have much relation to geography.

[10] I will discuss the case when there are royalty payments between the multinational firm and the host country firm. (section V).

[11] I will consider the case when there is spillover effect in section IV.

R&D investment is assumed to be a fully deductible expense.[12] The cost of R&D is assumed to be γX where γ is the constant marginal cost of R&D.[13]

Unlike a multinational's international capital flow, it is not necessary to keep the previous constraint, $r=(1-t^s)F_x^m$. The multinational firm invests in R&D until the sum of net rate of return of the parent firm and the net rate of return of its subsidiary are equal to marginal cost of R&D:

$$F_x^* + (1-t^{*^S})(1-t^s)F_x^m/(1-t^*) = \gamma \tag{6}$$

However, the labor market equilibrium remains the same as the previous model: $F_l(L) = F_l^m(X, L^m)$.

At a non-cooperative Nash equilibrium, the host country has the first right to tax the profit of a subsidiary firm to maximize its own social welfare. The social welfare function for the host country is $F(L) + WL^m + t^s[F^m(X, L^m) - wL^m]$. The optimal tax rate on FDI in the host country is $X/(-dX/dt^s)$. That is, if the R&D elasticity in terms of the host tax rate is one, the optimal tax rate is always obtained. The higher the response of R&D to host tax rate on FDI $(-dX/dt^s)$, the lower the host tax rate on FDI. When the response is infinite, the tax rate is zero. The interpretation is that, if a large increase of t^s induces a small decrease in X, the host ountry makes some welfare gains by collecting more tax revenues with a small change of R&D investment. Otherwise, if a small increase of t^s induces a large change in X, the host country loses some tax revenues by decreasing the host taxable income from the subsidiary firm.[14] Totally differentiate of equation (6) and the labor market equilibrium for explicit expression for (dX/dt^s).[15] Therefore, the optimal tax rate in the host

---

[12] Generally, most countries deduct multinational firms' R&D expenses fully or partially. For example, American multinationals could deduct fully their R&D expenses against domestic income from 1981 ~ 1986. However, U.S. firms with foreign income are generally not permitted to deduct all their R&D expenditures in the United States against their domestic taxable incomes. See Hines(1991).

[13] According to Dasgupta(1986), the technological possibilities linking R&D inputs and innovative outputs do not display any economies of scale with respect to the size of firm in which R&D is taken. D'Aspremont and Jacquemin(1988) uses $(1/2)\gamma X^2$ as the R&D cost function, which is increasing and convex, reflecting the existence of diminishing returns to R&D expenditures.

[14] Many studies showed R&D price elasticity to be somewhere between 0 and 1.6. Mansfield (1986) estimates that the value is between 0.2 and 0.5. Berstein and Nadiri(1989) estimates that the value is between 0.4 and 0.5, while Hines(1991) estimates that the value is between 1.2 and 1.6, etc..

[15] At the labor market equilibrium, totally differentiating the equilibrium condition

$$dL^m = [-F_{lx}^m / F_{ll} + F_{ll}^m]\, dX$$

Totally differentiate of equation (6),

$$F_{xx}^* dX + [(1-t^{*^S})(1-t^s)][F_{xx}^m dX + F_{xl}^m dL^m] - [(1-t^{*^S})/(1-t^*)]F_x^{(m)} dt^s = 0$$

country in the process-innovating model is as follows:

$$t^s = [((1-t^*)F_x^*(F_{ll}+F_{ll}^m))/((1-t^{*^s})F_x^m(2F_{ll}+F_{ll}^m))] + [F_{ll}/(2F_{ll}+F_{ll}^m)] \quad (7)$$

The tax rate dictates that the higher the parent firm's net marginal productivity of R&D and the lower the subsidiary firm's net marginal productivity of R&D (but gross of the host country tax on FDI), the higher t^s. For the home country, it also taxes to maximize its own social welfare: $F^*(X, L^*)+(1-t^s)[F^m(X, L^m)-wL^m]-\gamma X$. The tax rate does not depend on home tax rates (t^*, t^{*^s}) but only depends on the R&D marginal productivity of both the parent firm and its subsidiary and the slope of the labor marginal productivity of both the host country firm and the subsidiary. Since a parent firm's high marginal productivity of R&D (F_x^*) and a low subsidiary firm's productivity of R&D (F_x^m) induces a low R&D response when the host tax rate changes, the host country makes some welfare gains at a high tax rate on FDI by collecting more tax revenues. Unlike an international capital flows case, the hose country may collect some tax revenues from foreign investment income[16]; whereas, like an international capital flows case, foreign source income.

Next, when the host country is a leader over the host country, the host country tax policy exhibits the same form as a non-cooperative Nash equilibrium. However, the home country behavior changes since (dt^s/dt^{*^s}) is not zero. The optimal tax rate in the home country is $t^*+X(1-t^*)(dt^s/dt^{*^s})/(1-t^s)(dX/dt^{*^s})$. The second term in the formula is the tax strategic effects which consider the effects of its choice of home country's tax rate on FDI. The sign of (dX/dt^{*^s}) is assumed to be negative. In other words, a higher tax rate on FDI induces a lower R&D investment. Then, the sign of the second term depends on (dt^s/dt^{*^s}). If (dt^s/dt^{*^s}) is less than zero [or $(dt^s/dt^{*^s})>0$], the tax rate at a Stackelberg equilibrium is greater (less) than that at a non-cooperative equilibrium. In other words, as the home country is a leader, if (dt^s/dt^{*^s}) is less than zero, the home country should raise t^{*^s} in order to get the higher net profit for the subsidiary firm from a lower host country tax. Otherwise, if (dt^s/dt^{*^s}) is higher than zero, the home country should lower t^{*^s} in order to get the higher net profit for the subsidiary firm from a lower rate of host taxation. Therefore, the Stackelberg tax rates are as follows (see Figure 2)[17]:

Using the above two equations, we can find (dX/dt^s), that is

$$dX/dt^s[(1-t^{*^s})]F_x^m(F_{ll}+F_{ll}^m)]/[(1-t^*)(F_{ll}+F_{ll}^m)F_{xx}^m+[(1-t^{*^s})(1-t^s)F_{ll}F_{xx}^m]$$

16 Only if F_x^* is zero, t^S is zero.

17 t^s is equal to $\{(1-t^*)(F_{ll}+F_{ll}^m)F_x^*+(1-t^{*^s})F_{ll}F_x^m\}/(1-t^{*^s})F_x^m(2F_{ll}+F_{ll}^m)$

$$a^s = [(1-t^{*^s})F_x^m(F_{ll}/(F_{ll}+F_{ll}^m)) + (1-t^*)F_x^*]/ \\ /[(1-t^{*^s})F_x^m - (1-t^*)F_x^m] \quad (8)$$

where

$$a^s = t^s/(1-t^s),\ \ \eta = (dt^s/dt^{*^s})(t^{*^s}/t^s), \text{ and } \varepsilon_x^* = -(t^{*^s}/X)(dX/dt^{*^s})$$

The above two tax rates depend on marginal productivity of R&D (F_x^* and F_x^m), slope of marginal productivity on labor of both the host country firm and the subsidiary (F_{ll} and F_{ll}^m) R&D elasticity (ε_x^*) and tax responsiveness (η). Figure 2 reveals that, when η is negative (case (a)), the optimal tax rate in the home country is always greater than that on domestic income. However, when η is positive (case (a′)), the optimal tax rate in the home country is lower than that on domestic income.[18]

Finally, the Pareto-optimal tax rate on FDI, which is the optimal home country or the optimal host country tax rate on FDI with reducting the home or the host country's social welfare, can be determined.

$$\text{Max} \quad SW = F(L) + F^m(L^m, X) - (1-t^s)F_x^m X \quad (9)$$
$$s.t \quad SW = F^*(L^*, X) + (1-t^s)[F^m(L^m, X)] - \gamma X (= SW^*)$$

To find out tax rates on FDI, form a Lagrangian $L = SW - \lambda(SW - SW^*)$ and maximiae the host country's social welfare, given the home country's social welfare. By manipulating $(\partial L/\partial t^s) = 0$ and $(\partial L/\partial t^{*^s}) = 0$, the host and home countries' tax rates are as follow:

$$t^s = (M * N) + O \quad (10)$$
$$t^{*^s} = t^* - P$$

where

$$M = \{(1-t^*)(F_{ll}+F_{ll}^m)F_x^* + (1-t^{*^s})F_{ll}F_x^m\}/(1-t^{*^s})F_x^m(2F_{ll}+F_{ll}^m)$$
$$N = 1 - [(1-t^{*^s})\lambda/(1-t^* + \lambda(t^* - t^{*^s}))],$$
$$O = \lambda(t^{*-t^{*^s}})/(1-t^* + \lambda(t^* - t^{*^s})),$$
λ = Largrangian parameter.

Compare the above tax rates on FDI with those at the Nash equilibrium, which

[18] Unless F_x^m is greater than $(1-t^*)F_x^*$, there is no optimal tax rates at the equilibrium, therefore, we consider only when F_x^m is greater than $(1-t^*)F_x^*$.

$t^s = M$ and $t^{*^s} = t^*$ and those in the traditional model, which $t^s = 0$ and $t^{*^s} = t^*$. First, the tax rate difference between at the pareto-optimal and at the Nash equilibrium implies that the host country tax rate on FDI depends on N and O, which are composed of the amounts of R&D investments, the home country's tax rates (t^* and t^{*^s}) and λ. N is lower than one and O is always positive since t^{*^s} is always lower than t^*. That is, when the decrease of the first term of the host country tax rate is lower than the value of the second term, the host country tax rate at the Pareto-optimal is higher than that at the Nash equilibrium, otherwise, the reverse occurs. The home country tax rate should be lower than that at the Nash equilibrium since P is positive. It supports the result of Pereira and Wang(1991), which shows the optimal home tax rate on FDI under international cooperation is no greater than the tax rate on domestic investment income. The economic reasoning is that, at the Nash equilibrium, the marginal social welfare for the host country is zero and the marginal social welfare for the home country is ambiguous, that is, $(\partial SW/\partial t^s) = 0$ and $(\partial SW^*/\partial t^s) = ?$, while the marginal social welfare for the home country is zero and the marginal social welfare for the host country is negative, that is, $(\partial SW^*/\partial t^{*^s}) = 0$ and $(\partial SW/\partial t^{*^s}) < 0$. Therefore, the Pareto-optimum tax rate for the host country depends on the sign of $(\partial SW^*/\partial t^s) < 0$. The tax rate for the home country is at a lower level compared with the Nash equilibrium since the optimal tax rate is required to equalize (in absolute value) the marginal social welfare for the home and the host countries.

Next, comparing the tax rates in the process-innovating model with those in the traditional model, the host country can collect some tax revenues depending on the amounts of R&D investments, the home country's tax rates and λ since $t^s \geq 0$.[19] The home country should also tax at a lower rate at Pareto-optimal than that in the international capital flows. The economic reasoning is that the host country can increase its tax rate on FDI to collect more revenues at a lower level of λ, which the Largrangian multiplier constitutes a measure of the effect of a change in the constraint via the given value $\overline{SW}$ on the optimal value of the objective function. From the worldwide point of view, the home country had better lower the tax rate on FDI to provide more R&D investments because of the characteristics of R&D.

In summary, at a Nash and Stackelberg equilibrium, the host country collects some tax revenues from FDI. At a Nash equilibrium, the home country taxes at $t^* = t^{*^s}$, and, at a Stackelberg equilibrium, the home tax rate depends on the host tax response to the home tax on FDI (dt^s/dt^{*^s}). In other words, when η is negative, the home country tax rate on FDI in the process-innovating model is greater than that in the traditional model. Otherwise, when η is positive, the reverse occurs. At the Pareto-optimal, the host tax rate depends on the amounts

[19] This section assumes that the host country's tax rate on FDI is always non-negative. That is, if $N > 0$, t^s is always positive and, otherwise, even if $N < 0$ and $t^s < 0$, $t^s = 0$ by assumption.

of R&D investments, the home country's tax rates (t^*, t^{*^s}) and λ. And, the home tax rate is lower than that at the Nash equilibrium and that in the traditional model.

Ⅳ. THE OPTIMAL TAXATION ON FDI WITH R&D SPILLOVERS

Firms undertaking R&D investment are unable to completely appropriate all of the benefits from their R&D projects. The public good characteristics of R&D investment imply that spillovers or externalities are associated with R&D investment. These effects of R&D spillovers lead to incentives for the change of tax treastment of FDI. Especially when there consists in the externalities or spillovers in R&D across countries, the tax rates for both the home country and the host country may be or may not be affected. That is, even if the host country firm does not invest in R&D, it receives some benefits by the total R&D investment from the multinational firm. This section analyzes the case of spillovers in R&D from the multinational firm to the host country firm. This section preserves all the framework and assumptions of section Ⅲ except R&D spillover effects. The aggregate production of the host country firm is $F(L-L^m, \beta X)$ where L^m is the total employed labor of the subsidiary firm, X is the amount of R&D and β is a parameter of R&D spillovers. The value of β is between zero and one. If $\beta=0$, appropriabilty of R&D investment is perfect (section Ⅲ case); if, $\beta=1$, R&D is a pure public good. However, the production functions for both the parent firm and its subsidiary are unchanged.

Even if there is R&D spillover from the multinational firm to the host country firm, the multinational firm does not change its R&D investment equals to equation (6) in section Ⅲ. Therfore, the amount of R&D underprovides from the worldwide prospective since the multinational firm cannot appropriate all of the benefits from its R&D investment. The labor equilibrium is also that $w=F_l(L, \beta X)=F_l^m(L^m, X)$ and $w^*=F_l^*(L^*, X)$.

When we analyze the optimal tax rate on FDI in the home country, it alters nothing compared with the case of without R&D spillovers for both Nash equilibrium and Stackelberg equilibrium, since the social welfare function, the production for the parent firm and its subsidiary are unchanged. That is, the home tax rate at a Nash equilibrium is t^* and at a Stackelberg equilibrium is $t^*+X(1-t^*)(dt^s/dt^{*^s})/(1-t^s)(dX/dt^{*^s})$. Therefore, R&D spillovers affect only on the tax rate on FDI in the host country. The host country maximizes its own social welfare (national income), $F(L-L^m, \beta X)+wL^m+t^s[F^m(X, L^m)-wL^m]$. The optimal tax rate on FDI in the host country follows,

$$t^s = M-(\beta F_x/F_x^m) \tag{11}$$

where

β= spillover parameter

based on the FOC of the host social welfare tunation, the total differentiate of equation (6) for the explicit expression of (dX/dt^s) and CRS production function.[20] The second term of the above expression is a spillover effect. At a Nash equilibrium, since the home country tax on FDI is t^*, the host country tax rate on FDI is $[((F_{ll}+F_{ll}^m)F_x^* + F_{ll}F_x^m - \beta F_x(2F_{ll}+F_{ll}^m))/F_x^m(2F_{ll}+F_{ll}^m)]$. A highter β induces a lower t^s. As expected, the optimal tax rate is always lower than that when there is no spillover. The economic interpretation is that, as the spillover effects of R&D increase, the host country should lower its own tax rate on foreign direct investment income to attract more benefits from R&D investment of the multinational firm. As the marginal productivity of R&D in the subsidiary firm increase, the host country should treat foreign direct investment income unfavorably to collect more tax revenues. And, the higher the marginal productivity of host country firm of R&D, the lower host country tax rate.[21] Therefore, Figure 2′ reveals that, when η is positive, the tax rate on FDI for the host country is always lower than that without R&D spillovers and, for the home country, is always higher than without spillovers.[22] Whereaser, when η is negative, the tax rates on FDI for both countries are always lower than that without R&D spillovers.

Finally, the Pareto-optimal tax rates with R&D spillovers are similar those in the process-innovating model without R&D spillovers. A pareto-optimum is found by finding (t^s, t^{*^s}) and λ such that the partial derivatives of the Lagrangian with respect to t^s and t^{*^s} are both zero. Then, the host and home countries′ tax rates are as follow:

$$t^s = (M*N) - (\beta F_x/F_x^m)^* Q + O \tag{12}$$
$$t^{*^s} = t^* - P - R$$

where

$$Q = (1-t^*)/((1-t^*) + \lambda(t^* - t^{*^s})$$
$$R = \beta F_x(1-t^*)/\lambda F_x^m(1-t^s).$$

[20] CRS production function posits that $-XF_{xx}^* = F_x^*$.

[21] Since $a^s = t^s/(1-t^s)$ where $t^s = M - (\beta F_s/F_s^m)$.

[22] At Figure2′, $B' - B = [-\beta F_x F_x^m((2F_{ll}+F_{ll}^m)/(F_{ll}+F_{ll}^m))^2]/[(F_x^m - (1-t^*)F_x^*)^2 + ((2F_{ll}+F_{ll}^m)/(F_{ll}+F_{ll}^m))(F_x^m - (1-t_x^*)\beta F_x]$

Like Section Ⅲ, as long as $F_x^m > (1-t^*)F_x^*$, B', is always lower than B.

The tax difference between at the Pareto-optimal and at the Nash equilibrium notes that, for the host country, the difference is ambiguous and, for the home country, the sign of difference is negative since the multinational firm undertaking R&D investment is unable to completely appropriate all of the benefits from its R&D investment at the Nash equilibrium. Comparing the tax rates without R&D spillovers with those with R&D spillovers, both countries should lower than their tax rates on FDI without R&D spillovers since Q and R are positive. The economic reasoning is that, the host country should lower its own tax rate to get some more benefits of R&D spillovers from more R&D investments and the home country should also lower the tax rate to get the benefits from the host country firm because of the R&D spillovers.

In summary, at a Nash equilibrium, the tax rates on FDI for the host country are lower than those without spillovers and, at a Stackelberg equilibrium, the tax differences between with spillovers and without spillovers depend on the tax responsiveness (η). At a Pareto optimum, the tax rates on FDI for both the host country and the home country are lower than those without R&D spillovers.

V. SUMMARY AND DISCUSSION

The above results are summarized at Table 1. In the international capital flows model, the host country does not tax on FDI and the home country tax on FDI and the home country taxes on FDI based on $t^{*^s} = t^*$ regardless of tax strategic aspects. Next, in the process-innovation model without R&D spillovers, at the Nash equilibrium, the host country taxes on FDI depending on the marginal values of R&D productivity for both the parent firm and its subsidiary (F_x^* and F_x^m). The higher F_x^* and the lower F_x^m, the higher t^s. The home country still taxes on FDI based on $t^{*^s} = t^*$. At the Stackelberg equilibrium, the two tax rates depend on not only marginal productivity on R&D (F_x^* and F_x^m) and the slope of marginal productivity on labor in the host country but also R&D elastictiy (ε_x^*) and tax responsiveness (η) (Figure 2.) At the Pareto-optimal, the host country tax rate on FDI could be positive and the home country taxes lower than t^*. Finally, in the process-innovation model with R&D spillovers, as expected, the tax rate on FDI at the Nash equilibrium in the host country should be lower than that when there is no R&D spillover effects. However, at the Stackelberg equilibrium, the tax difference between with spillovers and without spillovers depends on the tax responsiveness. At the Pareto optimum, the tax rates on FDI for both the host country and the home country are lower than those without R&D spillovers.

The analysis can be extended to the case when there is licensing for R&D from the multinational firm to the host country firm whether or not there is double tax agreement on royalty. In general, a licensing agreement stipulates that the licensee pay a royalty or license fee for the parent, know-how or trademark received from the licenser. Licensing can only occur if it raises related firms' profits. The multinational firm's incentive to license is clear as long as its profit increase. However, the developed model shows no licensing is optimal for the multinational firm. The host country firm may wish to use R&D to save production cost by paying royalties, when the profit of host country with licensing is greater than that without licensing.[23] There are more issues of royalty payments and transfer pricing between the parent firm and its subsidiary. These can also be extended from a revised model of the previous developed one.

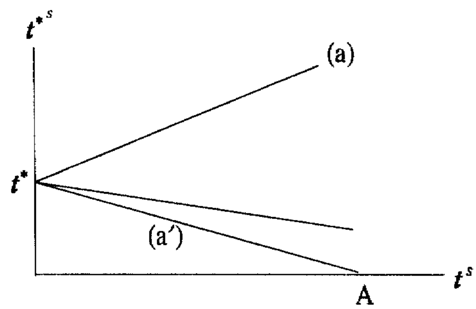
Ⅵ. CONCLUSION

This section used a stylized model to analyze the taxation of the multinational's investment in intangibles. I believe that, unlike the previous studies, I here provided a framework for analyzing the optimal taxation on foreign direct investment income in the process-innovation model whether or not there is R&D spillover effects. This section notes that there is only the productivity (cost-reducing) effect. That is, the multinational firm R&D investment generates changes in the output of the host country firm, without the latter firm's compensation. From a purely knowledge point of view, R&D spillovers constitute an unambiguous positive externality. The positive externality is potentially confronted with a negative effect of other's research due to competition. In other words, the R&D investment of a multinational firm lowers the profits and market value of the host country firm's R&D. Therefore, the current analysis should be extended to incorporate the rest of the potential role of R&D investment Bernstein and Nadiri (1989) noted that, in addition to the productivity effect, they added two other effects, that is, substitution effect and adjustment cost effect. It should also analyze the role of trade and the use of portfolio investment.

[Figure 1] Tax Rates on FDI at a Pareto Optimum

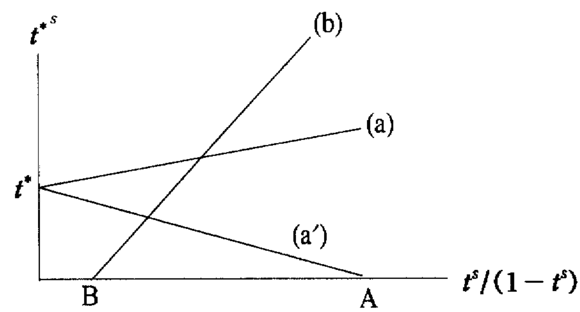
For the host country, slope is $-\lambda\varepsilon_k/(1-t^*)(\varepsilon_k-1+\lambda)$ and interecept is $\lambda\varepsilon_k t^*/(1-t^*)(\varepsilon_k-1+\lambda)$ and for the home country, shope is $-(1-t^*)/\lambda$ and intercept is t^*. (a) is when $(\varepsilon_k+\lambda)<1$ and (a′) is when $(\varepsilon_k+\lambda)>1$. A is equla to $\{\lambda t^*/(a-t^*)\}$. Unless the slope of (a′) is same as the slope of the home country, there is only one equilibrium, that is, $t^s=0$ and $t^{*^s}=t^*$.

[23] As long as the difference of $(F(L\ X)-F(L,\beta X))$ is positive, the host country firm want to be a licensee.



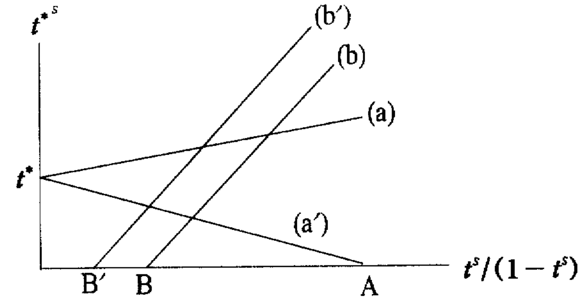
[Figure 2] Tax Rates on FDI at a Stackelberg Equilibrium W/O Spillover Effects

(a) or (a′) is a home country tax rate. (a) is when $\eta<0$ and (a′) is when $\eta>0$. (b) is a host country tax rate. A is equal to $t^*\varepsilon_x^*/(1-t^*)\eta$ and B is equal to $[F_{ll}/(F_{ll}+F_{ll}^m))F_x^m+(1-t^*)F_x^*]/[F_x^m-(1-t^*)F_x^*]$.



[Figure 2′] Tax Rates on FDI at a Stackelberg Equilibrium W/ Spillover Effects

(a) or (a′) is a home country tax rate. (a) is when $\eta<0$. (b) is a host country tax rate when there is no spillover and (b′) is a host country tax rate when there is spillover. B′ is equal to $[(F_{ll}/(F-ll+F_{ll}^m))F_x^m+(1-t^*)F_x^*-\beta F_x(1-t^{*s})((2F_{ll}+F_{ll}^m))]/[F_x^m-(1-t^*)F_x^*+\beta F_x(1-t^{*s})((2F_{ll}+F_{ll}^m)/(F_{ll}+F_{ll}^m))]$.



[Table 1] Summary of the Results

Strategic Aspects	Country	Traditional Model	Process-innovating Model	Spillover Effects	Explanation
Nash Equilibrium	Host	zero	$[F_x^*(F_{ll}+F_{ll}^m / F_x^m(2F_{ll}+F_{ll}^m)]+[F_{ll}/(2F_{ll}+F_{ll}^m)]$	$M-(\beta F_x/F_x^m)$	In process innovating model, the host country collects some tax revenues from FDI
	Home	t^*	t^*	t^*	
Stackelberg Equilibrium	Host	zero	$t^*-(1-t^*)\eta a^s/\varepsilon_x^m (F_{ll}/(F_{ll}+F_{ll}^m))+(1-t^*)F_x^*]/[(1-t^{*^s}) F_x^m-(1-t^*)F_x^*]$	$[(1-t^{*^s})(F_{ll}/F_{ll}+F_{ll}^m))F_x^m+(1-t^*)F_x^*-\beta F_x(1-t^{*^s})((2F_{ll}+F_{ll}^m/(F_{ll}+F_{ll}^m))]/[(1 t^{*^s}F_x^m-(1-t^*) F_x^*+\beta F_x(1-t^{*^s}) /(F_{ll}+F_{ll}^m))]$	$a^s=t^s/(1-t^s)$
	Home	t^*	$t^*-(1-t^*)\eta a^s/\varepsilon_x^*$	$t^*-(1-t^*)\eta a^s/\varepsilon_x^*$	
Pareto-optimal	Host	zero	M^*N+O	$(M^*N)-(\beta F_x/F_x^m)^* Q+O$	$M, Q, O>0$
	Home	t^*	t^*-P	t^*-P-R	$P, R>0$

REFERENCES

Alworth, J, (1988), *The Finance, Investment and Taxation Decisions of Multinationals*, New York, Basil Blackwell.

Bernstein, Jeffery, I., and M. Ishaq Nadiri, (1989), "Research and Development and Intra-industry Spillovers, An Empirical Application of Dynamic Duality," *Review of Economic Studies*, 56, 249-269.

Bernstein, Jeffery, I., and M. Ishaq Nadiri, (1991), "Product Demand, Cost of Function, Spillovers, and The Social Rate of Return to R&D," *National Bureau of Economic Research Working Paper Series*, No. 3625.

Bond, Eric W. and Larry Samuelson, (1989), "Strategic Behavior and the Rules for International Taxation of Capital," *The Economic Journal*, 99, 1099-1111.

Caves, Richard E., (1982), *Multinational Enterprises and Economic Analysis*, Cambridge: Cambridge University Press.

D'Aspremont, Claude, and Alexis Jacquemin, (1988), "Cooperative R&D in Duopoly with Spillovers," *American Economic Review*, 78, 1133-1137.

Feldstein, M. and D.G. Hartman, (1979), "The Optimal Taxation of Foreign Source Investment Income," *Quarterly Journal of Economics*, 93, 613-629.

Frisch, D., and D., Hartman, (1983), "Taxation and The Location of U.S. Investment Abroad," *National Bureau of Economic Research Working Paper Series*, No. 1241.

Gordon, Roger H., (1986), "Taxation of Investment and Savings in a World Economy," *American Economic Review*, 76, 1086-1102.

Gordon, Roger H., (1992), "Can Capital Income Taxes Survive in Open Economies?," *The Journal of Finance*, 57, No. 3, 1159-1180.

Griliches, Zvi, (1991), "The Search for R&D Spillovers," *National Bureau of Economic Research Working Paper Series*, No. 3768.

Hamada, K. (1966), "Strategic Aspects of Taxation of Foreign Investment Income," *Quarterly Journal of Economics*, 80, 361-375.

Hartman, David G., (1980), "The Effects of Taxing Foreign Investment Income," *Journal of Public Economics* 13, 213-230.

Hartman, David G., (1985), "Tax Policy and Foreign Direct Investment," *Journal of Public Economics*, 26, 107-121.

Hines, James R., Jr, (1991), "On the Sensitivity of R&D to Delicate Tax Changes, The Behavior of U.S. Multinationals in the 1980s," *National Bureau of Economic Research Working Paper Series*, No. 3930.

Hines, James R., Jr, (1993), "No Place Like Home: Tax Incentives and the Location of R&D by American Multinationals," *National Bureau of Economic Research Working Paper Series*, No. 4574.

Horst, T., (1977), "American Taxation of Multinational Firms," *American Economic Review*, 67, 376-89.

Horst, T., (1980), "A Note on the Optimal Taxation of International Investment Income," *Quarterly Journal of Economics*, 94, 793-798.

Hufbauer, G. C., (1975), "The Multinational Company and Direct Investment," In *International Trade and Finance: Frontiers for Research* (ed. P. B. Kenen). Cambridge:Cambridge University Press.

Huizinga, H., (1991), "National Tax Policies towards Product-innovating Multinational Enterprises," *Journal of Public Economics*, 44,1-14.

Huizinga, H., (1992), "The Tax Treatment of R&D Expenditures of Multinational Enterprises," *Journal of Public Economics*, 47,343- 359.

Jaffe, Adam, B., (1986), "Technological Opportunity and Spillovers of R&D : Evidence from Firms' Patents, Profits, and Market Value," *American Economic Review*, 76, 984-1001.

Kemp, M.C., (1962), "Foreign Investment and the National Advantage," *Economic Record*, 38, 56-62.

Kopits, G., F., (1976), "Taxation and Multinational Firm Behavior : A Critical Survey," *International Monetary Fund Staff Papers*, 23, 624-673.

Pereira, A., and L.J. Wang, (1990), "Optimal Taxation of Foreign Source Investment Income with International Cooperation," University of California, San Diego, Discussion Papers, #90-31.

Razin, Assaf and Efrain Sadka, (1990), "Capital Market Integration: Issues of International Taxation," *National Bureau of Economic Research Working Paper Series*, No. 3281.

Slemrod, J., (1988), "Effect of Taxation with International Capital Mobility," *National Bureau of Economic Research Working Paper Series*, No. 1188.

Slemrod, J., (1990), "The Impact of the Tax Reform Act of 1986 on Foreign Direct Investment to and from the United States," *National Bureau of Economic Research Working Paper Series*, No. 3234.