Research Paper

Tax Competition under the Incomplete Labor Market

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Introduction

Tax competition can generally be defined as mutually independent taxation authorities that are competing for specific purposes using tax bases or tax rates as policy instruments. Depending on the definition, a tax competitor can be the central government of a country or local governments in a certain country, and can be categorized as either tax competition among countries or tax competition among local governments.

In Korea, we know that there are few tax competition across local governments because the ratio of local tax revenues to total tax revenues is not large, and it is difficult for local governments to decide their own local tax rates. However, the existence of tax competition among other countries whose economic levels are like Korea's has been recognized as an important variable in policy establishment. As a typical example, looking at the history of changes in the corporate tax rate, which determines the capital tax rate, we can see that the corporate tax rate in Korea has changed in a quite similar direction as the corporate tax rates of OECD countries.

Furthermore, the corporate tax rate levels of major overseas countries has been constantly referred to in the dispute over whether the rate should be raised or lowered. For the supporters of lowering the corporate tax rate, their argument is that a corporate tax rate that is higher than that of competing foreign countries may accelerate the outflow of capital. Many people have the opinion, in particular, that if Korea raises the corporate tax rate, there will be an outflow of capital that is invested in Korea to other OECD countries due to the trend of decreasing corporate tax rates in these countries, which will lead to a decrease of the tax base.

These facts suggest that a study on tax competition, as an important field of study in Korea, can be quite useful for establishing actual policies. Unfortunately, the subject of tax competition in public economics is not a major field of study in Korea. There are a few preliminary domestic studies related to this field, and especially in the field of theoretical study, the number of domestic studies is smaller.[1] This phenomenon may be related to the specificity of the above-mentioned national system, however, considering the fact that studies in the field are being carried out continuously in other countries, the topic needs to be discussed in the context of Korean economy.

When we look at tax competition in relation to the establishment of actual policy, we need to think about the extent to which tax competition exists and what other factors may affect the competition. The extent to which tax competition exists in the international economic position of Korea is a matter to be analyzed through empirical study. As far as our knowledge, there are no study that analyze the degree of tax competition in Korea directly and explicitly.

Even though there are precedent studies analyzing other factors besides the corporate tax rate that can affect tax competition, it is a field where additional study is necessary. In a very simple economic environment, the corporate tax rate of each country can be perceived as the factor that has the greatest effect on the after-tax income of a firm. However, if the economic structure becomes complicated, it is hard to say that the tax rate is the sole instrument in tax competition. For example, a country with a large domestic market may have an attractive element for foreign capital to enter it compared to countries that do not have such a large domestic market, and thus a higher corporate tax rate can be set to accommodate foreign capital.

In addition to the tax rate, other economic conditions affect tax competition, and some prior studies that show the tax competition situation by simply setting the corporate tax rate have limitations and miss important factors. In order to overcome these limitations, tax competition models have been

1) Byung Ho Choi (2005), and Hae Myeong Ji (2003) have modeled the tax competition among local governments in Korea.

developed by reflecting various factors, and this study can also be understood as part of this effort.

In addition to corporate tax, there may be varying factors that can influence tax competition. The level of the corporate tax rate can be considered a policy instrument that affects the net profit of a firm or capital from investing a unit of capital. From this point of view, the corporate tax rate can be regarded as a source of variable cost, and other various variables that can affect variable costs can also act in the same or opposite direction of the corporate tax rate.[2)]

Even though there are many variables that can affect the corporate tax competition, one to consider in this study is **the labor market environment**. Such consideration is based on the fact that the labor market environment is very different even within economies of similar scale. For example, OECD countries have different level of labor market rigidities. While some countries, including the United States, have very flexible labor market structures for hiring and firing process, there are also countries where it is very rigid for firms to adjust the number of workers. The structure of the labor market is known in recent studies as a factor that directly affects the variable costs of firms and needs to be analyzed along with factors affecting the variable profitability of firms or capital. If the instrument of tax competition is mobile capital, we think that the labor market structure of a country, which can affect the mobility of capital, is a factor to be considered too.

Another variable considered in this study is the level of **trade openness** between two countries. Even though capital is motivated to move from an inefficient labor market to a more efficient one, the incentive to transfer capital can be greatly reduced if the trade cost between two countries is very high and production efficiency is deteriorated. Therefore, the effect of a labor market efficiency difference on tax competition is also affected by the level of trade openness between two countries.

2) The difference in market size, simply given the example above, means the difference in changeable sales that can be earned through the same investment, therefore it can be a variable to be considered in tax competition.

In the case of most existing tax competition models, it is assumed that the structure of the labor market does not differ from country to country. The analysis of tax competition is focused on capital movements under the efficient labor market assumption with the full employment.

Models under this assumption has clear strength in the simplicity, which makes the interpretation more intuitive, but it also has limitations. First, we cannot analyze the relationship between the labor market and corporate tax rate, assuming that the completeness of the labor market essentially blocks the possibility of government policy intervention in the labor market within the model. There may be no unemployment problem due to full employment, and the adjustment of employment is done immediately, so there would be no room for the balance of the labor market to change according to the change in corporate tax rate.

Next, we cannot analyze the issue of job loss or creation due to capital outflows or inflows because of tax competition. Even though capital inflows create additional production, there is no room to analyze the job creation effects of capital inflows because the existing economy is already in the full employment.

Finally, the assumption of a complete labor market may overestimate the effect of the tax rate on the degree of tax competition. Considering only the tax rate on capital as the main tax competition instrument, and excluding the main variables that may influence capital inflows, may lead to inaccurate policies. For example, in the U.S., where the labor market is very flexible, there is room for capital to flow in despite the high tax rate due to the low cost of the labor market. If U.S. policy makers do not consider labor market conditions, they will be lowering tax rates at competitive levels, which would be inadequate policy enforcement.

Based on the limitations of previous studies, this study theoretically analyzes how the degree of inefficiency of the labor market affects the tax competition between two countries in the situation where the labor market is inefficient and trade between the two countries is possible.

This study is composed as follows. First, in Chapter Ⅱ, we will set up a theoretical model, which is the main content of this study, and in Chapter Ⅲ, we will analyze the model's equilibrium conditions and tax competition patterns under equilibrium. Based on the results of the analysis, we will draw implications in Chapter IV.

Ⅱ

Model

1 Literature Review

The tax competition for capital between countries is a broadly studied topic. Wilson (1986) and Zodrow and Mieszkowski (1986) are among the earliest studies dealing with tax competition between countries. These two studies assumed an economy that produces and consumes two production factors with multiple governments. Each government supplies public goods with tax revenue secured by taxation on mobile capital among the two production factors. Under the circumstances, the tax rate increase of each government leads to capital outflows, which leads to inefficient tax competition in which the level of public goods supply in equilibrium is lower than the optimal level.

These early studies were improved in various perspectives. Bucovetsky (1991) analyzed the tax competition between a large and small economy. A country with a large economy will demand large amounts of capital in the capital goods market, and if that country adjusts the tax rate on capital, the return on world capital markets will be greatly influenced. Thus, a large country can have a higher tax rate in equilibrium of tax competition than a small country can.

Another development from the initial model that we want to introduce is a tax competition model with the consideration of trade. Many tax competition models consider only a homogeneous-good and thus, naturally exclude trade from the model. However, Wilson (1987) built a model where homogeneous countries are focused only on capital-intensive goods or labor-intensive goods and then trade them with each other, introducing two different goods with different production technologies. Countries with a lower tax rate on capital will encourage capital inflows to produce capital-intensive goods, and wage levels will also rise because of increased total capital. Countries with a higher tax rate on capital will encounter outflows of capital and a low wage level, but the supply of a high level of public goods can be an optimal choice.

The tax competition models most relevant to this study are the ones that consider the incomplete labor market. Most tax competition models are based on the assumption that the labor market is complete. However, most countries in the real world have minimum wage systems, and in most European countries wages are determined as a result of collective wage bargaining rather than individually depending on labor productivity.

There are several papers that analyze tax competition in the context of labor market modeling, assuming that wages are determined through bargaining between unions and firms. Lehner and Verbon (1996) are known as the first researchers who attempted this type of labor market modeling, and after that Fuest and Huber (1999), Richter and Schneider (2001), Koskela and Schob (2002), Leite-Monteiro, Marchand and Pestieau (2003), Eichner and Upmann (2012), and Exbrayat, Gaigne and Riou (2012) have modeled labor market incompleteness in a similar way.

The assumptions of the studies are somewhat different in detail. In particular, there are differences in the number of governments in the proposed economy where the number is two or N, and there are also different assumptions about how to use tax revenues. However, in all the studies mentioned above, they conclude that the structure in which wages are determined by bargaining between unions and firms has a meaningful impact on the degree of tax competition. When the labor market is incomplete, tax competition will be eased compared to a complete labor market, and therefore it is possible to levy positive (+) tax on capital under equilibrium.

The studies of Boadway, Cuff and Marceau (2002), and Sato (2009) differ from the above-mentioned studies in the way of modeling the incompleteness of the labor market. The two studies relieve the complete labor market assumption by using the search model of the labor, in which specific costs are incurred by firms or workers for job-offering and job-searching activities, and thus adjustment of the amount of workforce does not occur immediately in the labor market. Under these assumptions, Boadway, Cuff and Marceau (2002) show that the policy of attracting more people to search in the labor market by reducing taxation and reallocation of capital has a reciprocal substitutional nature. Therefore, governments that are unable to tax capital may compete to reduce reallocation, which in turn is likely to worsen the welfare of residents. Sato (2009) shows that when the labor market is incomplete, there may be a situation where too many public goods are supplied, exactly opposite to the results of existing models.

The above-mentioned models assume only one sector that produces mostly homogeneous-good. This assumption has the effect of eliminating the incentive of countries which are involved in tax competition to trade, and therefore excludes the competition which is occurring in international trade from the subject of analysis. Only the study by Exbarayat, Gaigne and Riou (2012) presumes an interstate trade situation, which assumes that firms in the homogeneous-good sector have a Cournot competition (quantity competition).

As we know, the study by Egger and Seidel (2011) is the only tax competition model that assumes an incomplete labor market within an industry structure that produces differentiated goods. In contrast to the studies mentioned above, Egger and Seidel (2011) modeled the incompleteness of the labor market using a fair wage theory, and concluded that if incompleteness in the labor market acts to strengthen tax competition, and the labor market becomes incomplete, the equilibrium tax rate will fall. The difference in such a conclusion needs to be reviewed in light of the fact that a fair wage model is not commonly used to model incompleteness of the labor market.

This study considers both sectors producing differentiated goods and homogeneous-good, as Egger and Seidel (2011) discussed. However, for the incompleteness of the labor market, we employ the search model used in the discussion by Helpman and Itskhoki (2010). As there are differentiated goods in both countries in the model, international trade exists in the model, and both countries are in a relationship of competing at the level of taxation on capital goods, which are internationally limited. The basic settings are modeling the incompleteness of the labor market in a general way, while considering the existence of international trade, showing a model that complements the deficiencies of previous studies.

2 General Environment

There are two countries in the model, A and B. To focus on analyzing the relationship between taxation policies and the labor market in both countries, we will assume that the two countries are very similar in many respects, except for labor market inefficiency. More specifically, it is assumed that the two countries have similar industrial structures and that the technologies used in each sector structure are also the same.

The labor endowments are also the same, and economic agents obtain utility by consuming goods produced in the two sectors and public goods supplied by the governments mentioned above. Workers search for jobs, and firms look to hire workers on the labor market, respectively, and they meet and bargain for wages. Inefficiency inevitably incurred in this process; the level of labor market cost perceived by each country is different from one another because the level of inefficiency in the labor market differs by country.

Finally, we will model that the two governments take the tax rate of counterpart as given and set tax rates that maximize the welfare of people in each country. The tax revenue obtained by taxation on capital is used to supply public goods, which are then linked back to households.

Let us explain in detail the assumed economic structure.

A. Sector

As mentioned earlier, there are two sectors in this economy. The first one is the homogeneous-good sector, in which one unit of a homogeneous-good is produced with one unit of labor. Homogeneous-good produced in both countries are completely the same. There is no trade in this sector as the two countries would not trade homogeneous-good where there is no difference in quality in the presence of trading costs.

The second sector is the differentiated goods sector. Each good produced in the differentiated goods sector has differentiated characteristics even if it is produced in the same sector, and therefore firms that produce each differentiated good face downward sloping demand curve, which then grants a kind of monopoly power. In other words, while differentiated goods are mutual substitute for each other, they form each demand group, and therefore there can be the international trade in the differentiated goods sector.

B. Utility Function

Agents consume goods produced in both sectors, and their utility is represented by the following utility function.

$$U_c = q_0 + \frac{Q^{\gamma} - 1}{\gamma} \quad \text{······ equation (II-1)}$$

In this equation, q_0 means homogeneous-good consumption and Q means differentiated goods consumption. The parameter γ represents the degree of differentiation between the homogeneous-good (q_0) and the differentiated goods (Q). γ has a value between 0 and 1, which means that the closer the value is to zero, the lower the substitution between homogeneous-good and differentiated goods, and if the value is closer to 1, the substitution between homogeneous-good and differentiated goods is higher. $\frac{Q^{\gamma} - 1}{\gamma}$ of the two terms constituting U_c takes the form of a logarithmic function when the value of γ approaches infinitely close to 0, and the form of simple linear function when the value of γ approaches infinitely close to 1. If this term takes the form of a linear function, there is no differentiation between homogeneous-good q_0 and the differentiated goods Q, and if this term takes the form of logarithmic functions, there is a certain differentiation between two goods.

Economic entities consume the public goods supplied by the government, in addition to the homogeneous-good and the differentiated goods, thereby obtaining another utility. If the government's public goods supply is expressed as G and the government's public goods supply brings the utility of $v(G)$ to economic entities, the final utility function of the economic entities can be expressed as follows:

$$U = q_0 + \frac{Q^{\gamma} - 1}{\gamma} + v(G) \quad \text{equation (II-2)}$$

The function $v(\bullet)$ in the above equation satisfies the general assumptions of the utility function. In other words, utility increases as public goods consumption increases, which is assumed to be concave, continuous and satisfying as follows simultaneously:

$$\lim_{G \to 0} v'(G) = \infty, \quad v(0) = 0 \quad \text{equation (II-3)}$$

Variable Q is the sum of the various goods produced in the differentiated goods sector through the constant elasticity of substitution (CES) function. That is, Q is represented by the sum of the differentiated goods q_j as follows.

$$Q = \left[\int_j q_j^{\beta} \right]^{\frac{1}{\beta}}, \qquad 0 < \beta < 1 \quad \text{equation (II-4)}$$

The value of β in the above equation is a variable that governs the elasticity of substitution between different q_j, and it is additionally assumed that the value of γ is smaller than the value of β in order to assume that the elasticity of substitution between products in the differentiated goods is higher than the elasticity of substitution between Q and q_0:

$$0 < \gamma < \beta < 1 \quad \text{equation (II-5)}$$

C. Demand for homogeneous-good and Differentiated Goods

By normalizing the price of a homogeneous-good q_0 to 1 ($p_0 = 1$), and using the utility function of the economic agents, we can express the optimizaion problem of the representative agent as followings:

$$\max \quad q_0 + \frac{Q^{\gamma}-1}{\gamma} + v(G) \quad s.t.\ E = q_0 + PQ \quad \cdots\cdots\cdots\cdots \text{equation (II-6)}$$

E stands for the total disposable income and P is the price index of Q.

When solving this optimization problem, it can be seen that the representative agent selects the following values q_0 and Q.

$$q_0 = E - Q^{\gamma} \quad \cdots\cdots\cdots\cdots \text{equation (II-7)}$$

$$P = Q^{-(1-\gamma)} \quad \cdots\cdots\cdots\cdots \text{equation (II-8)}$$

By inserting the values back into the utility function, the following indirect utility function can be derived.

$$V = E + \frac{(1-\gamma)Q^{\gamma}-1}{\gamma} + v(G) \quad \cdots\cdots\cdots\cdots \text{equation (II-9)}$$

The differentiated goods sector is in monopolistic competition. As a result, the firm j has a certain market share in setting the price for the differentiated goods produced by a firm j, which can be derived through the following process.

First, let's consider the utility maximization problem of the economic entity that demands both the different differentiated goods i and j.

$$\max \quad q_0 + \frac{Q^{\gamma}-1}{\gamma} + v(G) \quad s.t.\ E = q_0 + PQ,\ Q = \left[\int_j q_j^{\beta}\right]^{1/\beta}$$
$$\cdots\cdots\cdots\cdots \text{equation (II-10)}$$

In the above optimization problem, if we first find the conditions for q_i and q_j, we can obtain the following conditions:

$$\left[\int_j q_j^{\beta}\right]^{\frac{\gamma}{\beta}-1} q_i^{\beta-1} = p_i \quad \cdots\cdots\cdots\cdots \text{equation (II-11)}$$

$$\left[\int_j q_j^{\beta}\right]^{\frac{\gamma}{\beta}-1} q_j^{\beta-1} = p_j$$ ······························· equation (II-12)

By dividing these two equations, we can derive the following equilibrium condition:

$$q_i = q_j\left(\frac{p_i}{p_j}\right)^{-\frac{1}{1-\beta}}$$ ······························· equation (II-13)

Now, we multiply both sides of the equation by p_i and get the integral values on both sides.

$$\int p_i q_i \, di = \int q_j p_j^{\frac{1}{1-\beta}} p_i^{\frac{-\beta}{1-\beta}} di$$ ······························· equation (II-14)

Because the left side is the sum of the price multiplied by the demand for the differentiated goods, it means the expenditure used by the economic entity for the differentiated goods in the total expenditure. Putting this as E_1 we can derive the following equation:

$$E_1 = q_j p_j^{\frac{1}{1-\beta}} \int p_i^{\frac{-\beta}{1-\beta}} di$$ ······························· equation (II-15)

However, the price index P of Q, the CES sum of differentiated goods, is defined as follows:

$$P \equiv \left(\int p_i^{\frac{-\beta}{1-\beta}} di\right)^{-\frac{1-\beta}{\beta}}$$ ······························· equation (II-16)

Using this, the demand for individual goods q_j Using this, the demand for individual goods

$$q_j = E_1 p_j^{-\frac{1}{1-\beta}} \left(\int p_i^{-\frac{\beta}{1-\beta}} di \right)^{-1} \quad \text{.......................... equation (II-17)}$$

$$= E_1 p_j^{-\frac{1}{1-\beta}} \left[\left(\int p_i^{-\frac{\beta}{1-\beta}} di \right)^{-\frac{1-\beta}{\beta}} \right]^{\frac{\beta}{1-\beta}}$$

$$= E_1 p_j^{-\frac{1}{1-\beta}} P^{\frac{\beta}{1-\beta}}$$

Additionally using the relation $E_1 = PQ$ here,

$$q_j = E_1 p_j^{-\frac{1}{1-\beta}} P^{\frac{\beta}{1-\beta}} \quad \text{.. equation (II-18)}$$

$$= PQ p_j^{-\frac{1}{1-\beta}} P^{\frac{\beta}{1-\beta}}$$

$$= Q^{\gamma-1} Q p_j^{-\frac{1}{1-\beta}} Q^{\frac{\beta(\gamma-1)}{1-\beta}}$$

$$= Q^{-\frac{\beta-\gamma}{1-\beta}} p_j^{-\frac{1}{1-\beta}}$$

That is, the demand for each differentiated good j increases as the price of the differentiated goods decreases, and consumers consume the other differentiated good (Q) less.

D. Production Technologies

Let me explain the production technologies of the two sectors. First, let us assume that no production factors other than labor are required to produce homogeneous-good. In addition, let's assume that if one unit of labor is input, one unit of homogeneous-good is produced. In other words, when the homogeneous-good is expressed as q_0 and the amount of labor input is expressed as h, the production technology of the homogeneous-good sector can be expressed as follows.

$$q_0 = h \quad \text{equation (II-19)}$$

Let us further assume that there is no incompleteness in the factor market of the homogeneous-good sector and that the homogeneous-good sector is in the perfect competition. These two additional assumptions lead to the same level of wages in the factor market of the homogeneous-good sector, and when we standardize the price of a homogeneous-good to1, both price of the homogeneous-good and the wage level in the homogeneous-good market become 1.

Unlike the production technology of homogeneous-good, to produce differentiated goods, labor as well as capital should be used together. In this paper, we assume that one unit of capital is required for the production of differentiated goods, as assumed by Flam and Helpman (1987), Egger and Seidel (2011), and Sato (2009). In other words, it is assumed that one unit of capital goods is input as a fixed cost in producing a differentiated good and that the amount of labor required can be thought as variable cost. More specifically, it can be understood that one unit of capital is needed to establish a firm, and thereafter one unit of labor is needed to produce one unit of a good.

E. Factor Markets

There are three factor markets in each country. In the case of the homogeneous-good sector, there is a homogeneous-good labor market because labor is the only input factor. As mentioned above, we assume that there is no friction in the labor market of the homogeneous-good sector, and the amount of labor required is immediately employed.

In the case of the differentiated goods sector, there is a two-factor market because both labor and capital are required. First, the capital market is completely competitive without friction. There are a myriad of potential entrepreneurs, and they take the price of capital as a given. Therefore, the demand for capital is formed at the point where the profit of the differentiated goods producer is zero.

In other words, r_c, which represents the price of capital goods in country c, is determined by the following formula.

$$r_c = \max_h \{R(h) - w_c(h)h - b_c h\} \quad \text{equation (II-20)}$$

Here, $R(h)$ is the total revenue of a firm, h is the amount of the firm's employment, $w_c(h)$ is the wage which changes depending on the amount of employment, and b_c represents labor market cost.

3 Choice of Firms and Inefficiency of the Labor Market

A. Firm

With the production technologies explained above, firms pursue profit maximization as follows. First, the homogeneous-good sector faces the following profit maximization problem.

$$\max \ p_0 q_0 - w_0 h_0 \quad s.t. \ q_0 = h_0 \quad \text{equation (II-21)}$$

When solving the above maximization problem, the result value $p_0 = w_0 = 1$ is obtained. That is, with the production technologies assumed above, the wage level is determined at the same level as the price of the homogeneous-good in the homogeneous-good sector which is in the perfect competition.

Next, firm j, which operates in the differentiated goods sector in country $c \in \{A, B\}$, faces the following profit maximization problem.

$$\max \ \pi_j = R_j(h_j) - w_c(h_j)h_j - b_c h_j - r_c \quad \text{equation (II-22)}$$

Now, $R_j(h_j)$ is the total revenue of a firm, h is the amount of employment of the firm, and $w_c(h)$ is the wage of change depending on the amount of employment. Unlike the homogeneous-good sector, in which we assume a complete labor market, there is an inefficiency in the factor market of the differentiated goods sector, where additional costs are incurred whenever the labor is employed to produce. The additional cost is expressed as b_c in the above equation; each country has a parameter of labor market costs, because there is a difference in the labor market by country, but which is assumed to be homogeneous within a certain country.

The differentiated goods sector is in the monopolistic competition. For this reason, $R_j(h)$ has a type of function that depends on market demand for goods produced by firm j. The demand function for each differentiated good j, which is derived from the above, clearly shows the effect of the monopolistic competition. The demand of the differentiated goods j is represented by $Q^{-\frac{\beta-\gamma}{1-\beta}} p_j^{-\frac{1}{1-\beta}}$, and we can understand that the amount of q_j is determined according to the level of p_j.

In the absence of international trade between two countries, the total revenue of a firm that produces differentiated goods j can be expressed as:

$$R_j(h_j) = Q^{-\frac{\beta-\gamma}{1-\beta}} p_j^{-\frac{\beta}{1-\beta}} \quad \cdots\cdots \text{equation (II-23)}$$

$$= Q^{-(\beta-\gamma)} q_j^{\beta}$$

$$= Q^{-(\beta-\gamma)} h_j^{\beta}$$

In the above equation, if the second equality is derived directly from the relationship between demand and price of the differentiated goods j, the third equality is satisfied by the production technology in the homogeneous-good sector.

Now let's look at the trade of differentiated goods between countries A and B. Let's assume that there are additional costs associated with trade between the two countries in the iceberg type, following several international trade models. According to this assumption, the exporting country should ship

$\tau > 1$ units to deliver one unit of product to the trading partner country. When considering such trade cost, and when it is possible to trade in differentiated goods between the two countries, the total revenue of the firm j producing differentiated goods j may be modified as follows.

$$R_j(h_j) = \left(Q_c^{-\frac{\beta-\gamma}{1-\beta}} + \tau^{-\frac{\beta}{1-\beta}} Q_{-c}^{-\frac{\beta-\gamma}{1-\beta}} \right)^{1-\beta} h_j^{\beta} \quad \text{·················· equation (II-24)}$$

$$\equiv Z_c^{1-\beta} h_j^{\beta}$$

Here, Q_c means the consumption index of the differentiated goods in the home country where the exporting company is located, and Q_{-c} means the other country's consumption index of the differentiated goods. Z_c, which is the weighted sum of these two variables, can be interpreted as competitive strength in the differentiated goods market. When each country's consumption index increases, the value of Z_c decreases and the profitability of the firm decreases; if the consumption index of each country decreases, the value of Z_c increases and the profitability of a firm increases. The increase of differentiated goods consumption indices in both countries means that more firms producing differentiated goods enter the market, and this makes the market more crowded and leads to a decline in profitability for all firms.

It is noteworthy that Z_c, which means the profitability of a firm, has already been determined by the demand for each differentiated good, and that it is taken as given for the firms that produce differentiated goods. Each firm that produces differentiated goods will accept value Z_c as a given and determine the firm's production level by adjusting the amount of employment. That is, in the above equation, the part determined by each firm is the amount of employment h_j.

As mentioned earlier, even if trade is allowed between the two countries, homogeneous-good are not traded. The reason is that the quality of homogeneous-good produced in both countries is assumed to be exactly the same, as well as that the existence of iceberg type trade costs will have the effect of blocking the possibility of trade, where the international price of the good is standardized to 1.[3)]

For the homogeneous-good sector, a firm can immediately employ the number of workers it wants from the labor market, because it is assumed that there is no inefficiency in the entire labor market. Therefore, the wage level is determined at a level that maximizes the profit of the homogeneous-good sector. However, further consideration on how wages are determined in the labor market is needed, because in the differentiated goods sector it is assumed that the labor market is inefficient. In this study, we applied the Diamond-Mortensen-Pissarides inefficiency type, which has been broadly used in previous studies, to the labor market of the differentiated goods sector.

In the presence of this inefficiency, firms producing in the differentiated goods sector determine the wage level by bargaining with workers, and the wage level is also affected by the size of the labor force. Additional labor market costs must also be paid due to inefficiencies in employing workers. The structure of the labor market will be discussed in more detail in the next section.

B. The Structure of the Labor Market

There is inefficiency in the labor market of the differentiated goods sector due to search and matching. Search friction in the labor market is mainly caused by the following factors. First, when a firm wants to fill a vacancy, it may not be done immediately. In this case, it takes time and money to select the appropriate applicants by posting job openings. Additional time is required between the appropriate applicant and the firm in the search process.

In the Diamond-Mortensen-Pissarides type of labor market, it is assumed that matches between vacancies that a firm posts and the unemployed occur randomly. Many unemployed people who participate in the labor market are linked to a number of vacant jobs every minute, and the matching is done randomly without any specific direction. As a result, the number of matches that can occur at any given moment is decided by the number of vacancies

3) Even though there is no trade cost with the iceberg type, it may be reasonable to assume that there is no profit from trade, and therefore no trade between the two countries because the two goods are completely homogeneous.

and the number of unemployed people in the labor market. The labor market tightness is used to control the number of matches, which is defined as the ratio of the total number of jobs to the number of unemployed in the labor market.

Another cost in the labor market can be considered to be the one incurred in the process of dismissal. In a complete labor market, there is no additional cost to adjust the number of the labor force because it assumes that dismissal and employment occur immediately. However, in a labor market where search friction exists, the firing cost should also be considered.

In this study, the hiring and firing costs in the labor market are set as follows. First, firms must endure a certain amount of employment costs in matching the unemployed and employing them. As set out in Helpman and Itskhoki (2010), it is assumed that the employment costs of firms increase as labor market tightness increases. Next, some of the employed workers are dismissed without being put into production activities, and therefore results in dismissal costs. It is assumed here that σ of the total employees are dismissed.

If the number of unemployed workers in country c is H_c, and the number of unemployed workers is L_{DC}, labor market tightness can be expressed as:

$$x_c = \frac{H_c}{(1-\sigma)L_{DC}} \quad \cdots\cdots \text{equation (II-25)}$$

The total number of jobs that must be matched in the labor market is $\frac{H_c}{(1-\sigma)}$ because a certain percentage (σ) of the optimal amount of employment (H_c) that firms are willing to employ must be dismissed.

As the total number of jobs that should be matched against the number of job seekers (L_{DC}) increases, the hiring cost increases from the firms' standpoint. More specifically, the search cost of a firm is expressed by the following equation.

$$b_{hc} = a_c x_c^{\alpha} = a_c\left[\frac{H_c}{(1-\sigma)L_{DC}}\right]^{\alpha}, \quad a_c > 1,\ \alpha > 0 \quad \cdots\cdots \text{equation (II-26)}$$

$a_c > 1$ represents the efficiency of matching, that is, the degree of friction in the labor market of the country c, and $\alpha > 0$ is a parameter that determines the relationship between efficiency of matching and tightness. Value a_c becomes a larger value as firms post more vacancies and match up with the unemployed, and in this report, we assume that value α is the same between two countries, while a_c is different.

The firing cost that firms recognize is modeled as what is incurred per employee who firms must dismiss. By the probability of σ, some of the workforce once matched turns out to be unsuitable for a firm, in which case, the firm will dismiss the employee, paying the cost of b_{fc}. The firing cost can be estimated in advance because the parameter σ, which symbolizes the suitability of matching between a firm and a worker, is assumed to be the same for all workers, and by using it, the labor market cost b_c that a firm, acting in a country c, should be recognized to hire an employee can be expressed as:

$$b_c = \frac{b_{hc} + \sigma b_{fc}}{1-\sigma} \quad \cdots\cdots \text{equation (II-27)}$$

$$= \frac{a_c x_c^{\alpha} + \sigma b_{fc}}{1-\sigma}$$

The part of the equation above $(a_c x_c^{\alpha} + \sigma b_{fc})$ is the cost of employing a person in the pre-dismissal phase, which is simply determined by the sum of the hiring cost, and the firing cost that is incurred resulting from the probability of σ. However, not all employed workers work in that firm, so it must employ $\frac{1}{1-\sigma}$ workers to select one suitable employer. The labor market cost per worker who is actually hired and working is determined by b_c, amending this in the denominator.

C. Wage Bargaining and Profit Maximization

The vacancies of a firm matched in the differentiated goods sector and workers for the job follow wage bargaining in the same manner as proposed by Stole and Zweibel (1996). They illustrated the process of wage bargaining in an environment where an additional unit of a worker's employment affects the wages of all existing workers, which can be expressed as:

$$\frac{\partial}{\partial h}\left[R_j(h)-w_j(h)h\right]=w_j(h) \quad \cdots\cdots\cdots\cdots \text{equation (II-28)}$$

Here, the left side represents the marginal profit of a firm when one more unit of labor is employed, and the right side represents the marginal return to the worker, that is, the wage. If we solve the partial differential equation above, we can derive the following wage determination formula.

$$w_j(h)=\frac{\beta}{1+\beta}\frac{R_j(h)}{h} \quad \cdots\cdots\cdots\cdots \text{equation (II-29)}$$

Therefore, the profit maximization problem faced by firm j of the differentiated goods sector in country c mentioned above can be rewritten as follows.

$$\begin{aligned}\max\ \pi_j &= R_j(h_j)-w_c(h_j)h_j-b_c h_j-r_c \quad \cdots\cdots\cdots\cdots \text{equation (II-30)}\\ &= \frac{1}{1+\beta}R_j(h_j)-b_c h_j-r_c\end{aligned}$$

The following equilibrium can be derived from the primary conditions of maximization by solving the problem:

$$\begin{aligned}h_c &= \left(\frac{\beta}{b_c(1+\beta)}\right)^{\frac{1}{1-\beta}}Z_c=\left(\frac{\beta}{b_c(1+\beta)}\right)^{\frac{1}{1-\beta}}\left(Q_c^{-\frac{\beta-\gamma}{1-\beta}}+\tau^{-\frac{\beta}{1-\beta}}Q_{-c}^{-\frac{\beta-\gamma}{1-\beta}}\right)\\ &= \left(\frac{\beta}{b_c(1+\beta)}\right)^{\frac{1}{1-\beta}}Q_c^{-\frac{\beta-\gamma}{1-\beta}}+\left(\frac{\beta}{b_c(1+\beta)}\right)^{\frac{1}{1-\beta}}\tau^{-\frac{\beta}{1-\beta}}Q_{-c}^{-\frac{\beta-\gamma}{1-\beta}}\\ &= h_{dc}+h_{xc}\end{aligned}$$

$$\cdots\cdots\cdots\cdots \text{equation (II-31)}$$

All companies in the differentiated goods sector demand the same amount of labor, because all firms in that sector are homogeneous. Therefore, the subscript j is replaced with c. In this equation, h_{dc} is the number of workers employed for domestic supply in country c, and h_{xc} is the number of workers employed for export to the other country.

If you put the above-mentioned equilibrium amount of employment into the wage determination formula, the equilibrium wage level can be summarized as follows:

$$w(h) = \frac{\beta}{1+\beta}\frac{R(h)}{h} = \frac{\beta}{1+\beta}\frac{Z_c^{1-\beta}h^{\beta}}{h} = \frac{\beta}{1+\beta}Z_c^{1-\beta}h^{\beta-1} \quad \cdots \text{equation (II-32)}$$

$$= \frac{\beta}{1+\beta}Z_c^{1-\beta}\left(\frac{\beta}{b_c(1+\beta)}\right)^{-1}Z_c^{\beta-1}$$

$$= b_c$$

In other words, we can see that the wage level in the differentiated goods sector in one country is equal to the labor market cost incurred in the labor market. In addition, the expected wage (=$x_c w$) in the differentiated goods market and the expected wage (= 1) in the homogeneous-good market must be the same, because the unemployed can move freely between two different sectors in one country. That is, the following equilibrium is established:

$$w^* = b_c = \frac{a_c x_c^{\alpha} + \sigma b_{fc}}{1-\sigma} = \frac{1}{x_c} \quad \cdots\cdots\cdots\cdots\cdots \text{equation (II-33)}$$

The endogenous parameter $x_c (= \frac{H_c}{(1-\sigma)L_{DC}})$ is determined by other parameters in the above equation, and b_c, which is a function of x_c, is also directly determined by an exogenous variable in the above equation, because in the above equation, the variables except x_c are exogenous parameters. With this in mind, we treat b_c as a parameter of labor market incompleteness. In other words, a higher level of b_c means a high labor market incompleteness and a lower level of b_c means a low labor market incompleteness.

4 Government and Social Welfare

Each household in country c has L_c unit of labor and $\widehat{K}_c$ unit of capital. Each household gains utility by consuming income earned from the amount of labor and capital allocated. The government of country c determines the capital tax rate at a level that maximizes the social welfare of the households, and then the tax revenue obtained is returned to households by supplying public goods.

This process can be expressed as the following equation. First, the gross income of households in country c is the labor income and capital income, where for labor income, it can be obtained by engaging in the homogeneous-good sector or the differentiated goods sector. The income level of the total L unit of the labor force becomes $L_c * 1 = L_c$, because workers will move to both labor markets until the expected income in both labor markets reaches the same level.

Next, the capital income is obtained by investing in the home country or the other country. If the tax rate on capital imposed by country c is t_c, the capital income obtained by investing all the capital of the $\widehat{K}_c$ in country c can be expressed as $(1-t_c)r_c\widehat{K}_c$.4) By combining the two, it can be expressed that the total income of households in country c is as follows:

$$E_c = L_c + (1-t_c)r_c\widehat{K}_c \quad \text{equation (II-34)}$$

4) Even though a part of the capital is invested in a foreign country, the expression of capital income does not change, because capital will move internationally to the extent that the real return of capital is the same in the two countries.

In other words, the total income level of country c depends on the endowment of labor and capital.

Using the total income of the household, the indirect utility function of country c can be expressed as follows:

$$V_c = E_c + \frac{(1-\gamma)Q_c^{\gamma} - 1}{\gamma} + v(G_c) \quad \cdots\cdots\cdots\cdots\cdots\cdots \text{equation (II-35)}$$

$$= L + (1-t_c)r_c\widehat{K}_c + \frac{(1-\gamma)Q_c^{\gamma} - 1}{\gamma} + v(G_c)$$

The government of country c determines the tax rate on capital invested in the country and supplies public goods G_c based on the tax revenues obtained. When the total amount of capital invested in country c is expressed as K_c, then the budget constraint equation of the country c government can be expressed as:

$$G_c \leq t_c r_c K_c \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \text{equation (II-36)}$$

III

Tax Competition

We have introduced the basic environment that constitutes this economy. In this chapter, we will examine the equilibrium conditions of the basic environment set out above, and then derive the equilibria to see the optimal choice of the government in each equilibrium.

1 Equilibrium Conditions

The balance of the economic environment described above can be broadly divided into the optimal selection area of each firm (or person) and the equilibrium of aggregate variables of the economy. The continnum of households of size 1 takes the aggregate variables as given and solve its optimization problem. Each household is given L_c units of labor and $\widehat{K}_c$ units of capital.[5)] As a result of the optimization, the labor force of each household participates in the labor market of the differentiated goods market or the homogeneous-good market and obtains the expected wage. And the capital goods of each household earn capital income in the capital goods market formed internationally with the result of the optimal decision of capital. The sum of the labor income and the capital income earned leads to the purchase of homogeneous-good and differentiated goods, and the economy flows.

5) The labor and the capital allocated in the economy are also decided as L_c and $\widehat{K}_c$, because the size of the continuously arranged households is one.

The equilibrium of aggregate variables of the economy consists of the sum of the result of each optimization. The sum of labor used by each firm constitutes the total amount of employment (H_c) in the differentiated goods sector of country c, and the sum of each demand constitutes the total demand for the total differentiated goods (Q_c). In addition, L_{DC}, the size of the labor force working in the differentiated goods labor market among the total labor L_c, can also be derived from the equilibrium of the labor market with H_c.

The endogenous variables derived from the equilibrium are $h_{dc}, h_{xc}, \pi_c, r_c, H_c, L_{DC}, Q_c$ First, the endogenous variables determined by the optimal choice of each firm and each person are the wage level, each firm's amount of employment, the amount of production, and the profit level in the differentiated goods market. Each equilibrium can be summarized as follows. First, the optimal amount of employment of a firm is expressed as follows.

$$h_c = \left(\frac{\beta}{b_c(1+\beta)}\right)^{\frac{1}{1-\beta}} Z_c = q_c \qquad \cdots\cdots\cdots\cdots\cdots\cdots \text{equation (III-1)}$$

$$h_{dc} = \left(\frac{\beta}{b_c(1+\beta)}\right)^{\frac{1}{1-\beta}} Q_c^{-\frac{\beta-\gamma}{1-\beta}} = q_{dc}$$

$$h_{xc} = \left(\frac{\beta}{b_c(1+\beta)}\right)^{\frac{1}{1-\beta}} \tau^{-\frac{\beta}{1-\beta}} Q_{-c}^{-\frac{\beta-\gamma}{1-\beta}} = q_{xc}$$

We can see that the endogenous variables on the left side are all expressed as functions of b_c, Q_c, and Q_{-c} on the right side. b_c among these is determined directly from labor market parameters by formula (II-33) regardless of other endogenous variables, and therefore, we can in fact understand that the optimal amount of a firm is a function of Q_c and Q_{-c}, indicating the size of domestic and overseas markets. It is important to notice that h_{xc}, which symbolizes the amount of employment hired for the export of differentiated goods, is a function of b_c rather than b_{-c}, because the employment occurs in domestic c while being affected by the total size of the foreign market. Finally, we can see that the amount of employment and the amount of production coincide because one unit of labor leads to one unit of a differentiated good.

By applying the optimal amount of employment derived from the above equation, the profit level of a firm engaged in the differentiated goods sector of country c can be expressed as follows [6]:

$$\pi_c = \frac{1-\beta}{1+\beta}\left(\frac{\beta}{b_c(1+\beta)}\right)^{\frac{\beta}{1-\beta}} Z_c - r_c \quad \cdots\cdots \text{equation (III-2)}$$

The endogenous variables on the right side of the above equation are Q_c, Q_{-c}, and r_c. When the total amount of capital goods flowing into country c is given as K_c, a myriad of firms will compete to acquire the limited capital, and the competition will continue until the profit of each firm becomes zero. That is, the above equation yields the following equilibrium return on capital:

$$r_c = \frac{1-\beta}{1+\beta}\left(\frac{\beta}{b_c(1+\beta)}\right)^{\frac{\beta}{1-\beta}} Z_c \quad \cdots\cdots \text{equation (III-3)}$$

In addition, the after-tax returns on capital in both countries should be the same, because capital can move across the border. That is,

$$(1-t_A)r_A = (1-t_B)r_B \quad \cdots\cdots \text{equation (III-4)}$$

The total amount of employment H_c in the differentiated goods sector can be expressed as multiplying the amount of employment h_c of a firm and the number of firms in the differentiated goods sector of country c:

6) The firms that are engaged in the differentiated goods sector meet the same amount of demand and earn the same level of profits because they are homogeneous except for producing distinct differentiated goods.

$$H_c = h_c \times K_c \quad \text{equation (III-5)}$$

The total labor L_c is divided into the differentiated goods sector (L_{DC}) and the homogeneous-good sector (L_{HC}), each of which is expressed by equation (II-25) as follows:

$$L_{DC} = \frac{H_c}{(1-\sigma)x_c} \quad \text{equation (III-6)}$$

$$L_{HC} = L_c - L_{DC}$$

The last endogenous variables, Q_c and Q_{-c}, can be derived by the following procedure. In equation (II-4), Q_c represents the sum of the differentiated goods produced in country c for domestic demand and the CES of the differentiated goods imported from the other country. That is,

$$Q_c = \left[K_c q_{dc}^{\beta} + (2K - K_c) q_{x(-c)}^{\beta}\right]^{\frac{1}{\beta}} \quad \text{equation (III-7)}$$

When applying equation (II-31), the following equation can be derived.

$$Q_c = \left[K_c h_{dc}^{\beta} + (2K - K_c) h_{x(-c)}^{\beta}\right]^{\frac{1}{\beta}}$$

$$= \left[K_c \left(\frac{\beta}{(1+\beta)b_c}\right)^{\frac{\beta}{1-\beta}} Q_c^{-\frac{\beta(\beta-\gamma)}{1-\beta}} + (2K - K_c)\tau^{-\frac{\beta^2}{1-\beta}} \left(\frac{\beta}{(1+\beta)b_{-c}}\right)^{\frac{\beta}{1-\beta}} Q_c^{-\frac{\beta(\beta-\gamma)}{1-\beta}}\right]^{\frac{1}{\beta}} \quad \text{equation (III-8)}$$

Summarizing this again, the equilibrium value of Q_c can be derived as follows.

$$Q_c = \left(\frac{\beta}{1+\beta}\right)^{\frac{1}{1-\gamma}} \left[K_c b_c^{-\frac{\beta}{1-\beta}} + (2K - K_c)\tau^{-\frac{\beta^2}{1-\beta}} b_{-c}^{-\frac{\beta}{1-\beta}}\right]^{\frac{1-\beta}{\beta(1-\gamma)}} \quad \text{equation (III-9)}$$

2 Government's Optimal Choice

In this section, we will explain the decision of governments that thoroughly understands the market equilibrium explained above to maximize its agents ' utility, and what kind of equilibrium the decisions in both countries lead to. As described above, a government supplies public goods to households based on tax revenues earned by the taxation on capital. Therefore, the policy instrument of a government is the capital tax rate, and the two governments face the problem of determining tax rates by considering the tax rate that the other government is expected to set as a given.

We will assume that a government aims to maximize the utility of households, as in several studies.[7] That is, a government chooses to maximize the indirect utility function derived from the previous section. The indirect utility function of this economy is derived from equation (III-35) as follows:

$$V_c = L + (1-t_c) r_c \widehat{K_c} + \frac{(1-\gamma) Q_c^{\gamma} - 1}{\gamma} + v(G_c) \quad \text{············ equation (III-10)}$$

The variables on the right side of equation (III-10) can be expressed as a function of the capital tax rates of the two countries with other exogenous variables. The tax rate determines the amount of capital invested in each country, because it changes the after-tax return on capital invested in each country. At the point where the amount of capital equals the number of firms in the differentiated goods market, the number of firms and the total amount of production are determined in the differentiated goods sector. Therefore, it can be expressed as $r_c = r_c(t_c, t_{-c})$, $Q_c = Q_c(t_c, t_{-c})$, $K_c = K_c(t_c, t_{-c})$, so that the indirect utility function of country c can be rewritten as follows.

7) There are also opinions that a government aims to maximize tax revenue without maximizing social welfare (see Brennan and Buchanan (1980)).

$$V_c = L + (1-t_c)\, r_c(t_c\,,\, t_{-c})\, \widehat{K}_c + \frac{(1-\gamma)\, Q_c^{\gamma}(t_c, t_{-c}) - 1}{\gamma} + v(t_c r_c(t_c, t_{-c})\, K_c(t_c, t_{-c}))$$

·· equation (III-11)

That is, all of the equilibrium interest rate (r_c), the amount of capital (K_c) invested in country c, and the amount of differentiated goods consumption (Q_c) are determined by the capital tax rates of two countries.

The optimal tax rate is defined as the tax rate that maximizes the indirect utility function of the home country by taking the tax rate of the other country as a given. When equation (III-11) is continuous and differentiable in t_c and t_{-c}, the optimal tax rate $t_c(t_{-c})$ can be derived by finding the maximum point for t_c on the right side of the equation.

When the above indirect utility function is continuous and differentiable near the point of $t_c = t_{-c}$, t_c and t_{-c}, which maximize the objective function of both countries, can be obtained. Therefore, when given appropriate parameter values, the Nash equilibrium of inter-government tax competition is determined by the following first-order condition.

$$-r_c\widehat{K}_c + (1-t_c)\frac{\partial r_c}{\partial t_c}\widehat{K}_c + (1-\gamma)\, Q_c^{\gamma-1}\frac{\partial Q_c}{\partial t_c} + \frac{\partial v_c}{\partial G_c}\left[r_c K_c + t_c K_c \frac{\partial r_c}{\partial t_c} + t_c r_c \frac{\partial K_c}{\partial t_c}\right] = 0$$

·· equation (Ⅲ-12)

The above equation is obtained by differentiating the indirect utility function V_c with t_c. We can refer to the market equilibrium derived from the previous chapter to decide the values of $\frac{\partial Q_c}{\partial t_c}, \frac{\partial r_c}{\partial t_c}$, and $\frac{\partial K_c}{\partial t_c}$. Looking closely at the market equilibrium conditions derived from the previous section, we can understand that Q is a function of K, Z is a function of Q, and r is a function of Z. Therefore, using the chain rule, we can write the equation as follows.

$$\frac{\partial Q_c}{\partial t_c} = \frac{\partial Q_c}{\partial K_c}\frac{\partial K_c}{\partial t_c}$$

·· equation (III-13)

$$\frac{\partial r_c}{\partial t_c}=\frac{\partial r_c}{\partial Z_c}\frac{\partial Z_c}{\partial Q_c}\frac{\partial Q_c}{\partial K_c}\frac{\partial K_c}{\partial t_c}+\frac{\partial r_c}{\partial Z_c}\frac{\partial Z_c}{\partial Q_{-c}}\frac{\partial Q_{-c}}{\partial K_c}\frac{\partial K_c}{\partial t_c}$$ ········ equation (III-14)

The first equation shows the relationship where the tax rate determines the investment of capital and the consumption index Q is determined by the capital invested K. The first term on the right-hand side of the second equation shows the relationship where the investment return r is determined by the amount of capital invested, the domestic production of domestic firms, and the profitability of the domestic market, and the second term shows that the export amount of a foreign firm affects the profitability of the domestic market, and then the return on investment. Derivatives $\frac{\partial Q_C}{\partial K_C}, \frac{\partial r_C}{\partial Z_C}\frac{\partial Z_C}{\partial Q_C}$ of each term can be derived by differentiating the market equilibrium condition equation.

First, value $\frac{\partial Q_C}{\partial K_C}$ can be derived by differentiating Q_C by K_C, that is, using the equation $\frac{\partial K_C}{\partial t_C}=-\frac{\partial K_{-C}}{\partial t_C}$, which means that the capital inflow to one country is equal to that of the outflow from the other country.

$$\frac{\partial Q_C}{\partial K_C}=\left(\frac{\beta}{1+\beta}\right)^{\frac{1}{1-\gamma}}\frac{1-\beta}{\beta(1-\gamma)}\left[K_C b_C^{-\frac{\beta}{1-\beta}}+K_{-C}(\tau^{\beta}b_{-C})^{\frac{-\beta}{1-\beta}}\right]^{\frac{1-\beta}{\beta(1-\gamma)}-1}\left[b_C^{-\frac{\beta}{1-\beta}}-(\tau^{\beta}b_{-C})^{-\frac{\beta}{1-\beta}}\right]$$
··· equation (III-15)

In the above equation, the sign in the last parenthesis, $\left[b_C^{-\frac{\beta}{1-\beta}}-(\tau^{\beta}b_{-C})^{-\frac{\beta}{1-\beta}}\right]$, has a positive value according to the symmetric balance assumption that the sizes of b_C and b_{-C} are not significantly different. Therefore, this equation shows how the amount of differentiated goods production increases as the amount of capital increases.

Next, Z_C is differentiated into Q_C and Q_{-C} to derive the following.

$$\frac{\partial Z_C}{\partial Q_C} = -\frac{\beta-\gamma}{1-\beta} Q_C^{-\frac{\beta-\gamma}{1-\beta}-1} \quad \cdots\cdots \text{equation (III-16)}$$

$$\frac{\partial Z_C}{\partial Q_{-C}} = -\frac{\beta-\gamma}{1-\beta} Q_{-C}^{-\frac{\beta-\gamma}{1-\beta}-1} \tau^{-\frac{\beta}{1-\beta}} \quad \cdots\cdots \text{equation (III-17)}$$

These equations show the relationship between the amount of consumption and market profitability. As the number of firms increases or the amount of production of each firm increases, the consumption index Q increases, and then for an individual firm, the profitability of the market decreases. Therefore, the right sides of both equations are negative.

Finally, let's look at how the profitability of the market affects the return on capital, differentiating r_C by Z_C.

$$\frac{\partial r_C}{\partial Z_C} = \frac{1-\beta}{\beta}\left[\frac{\beta}{b_C(1+\beta)}\right]^{\frac{1}{1-\beta}} b_C \quad \cdots\cdots \text{equation (III-18)}$$

If a firm gets a bigger return in a market, the return on capital will also increase, and of course the right side of this equation will be positive.

Applying the equations summarized above to the first-order condition, the equilibrium is determined at the point where both conditions are satisfied at the same time.

3 Types of Equilibrium

Before describing the aspect of equilibrium in more detail, let's look at the types of equilibrium according to the change of parameter values. In equilibrium, the endogenous variables of Q_c, Z_c, r_c, and K_c change together as value t_c changes. Among these variables, value K_c, which indicates the amount of capital goods invested in country c, decreases monotonically as t_c increases. Therefore, to improve the reader's understanding, we will treat value K_c as a policy variable of a government. The government's choice to change t_c is consequently equivalent to controlling K_c, because the relationship between t_c

and K_c is monotonically determined.

We explained the relationship of endogenous variables above. We showed that value r_c is determined by Z_c, and the two values have a positive relationship, and that Z_c is again a function of Q_c and Q_{-c}, and a decreasing function of both of the two. Therefore, we can explain the change of other endogenous variables, examining how Q_c and Q_{-c} change as K_c changes.

The derivative of Q_c with respect to K_c of confirmed in the previous section is as follows:

$$\frac{\partial Q_c}{\partial K_c} = \left(\frac{\beta}{1+\beta}\right)^{\frac{1}{1-\gamma}} \frac{1-\beta}{\beta(1-\gamma)} \left[K_c b_c^{-\frac{\beta}{1-\beta}} + K_{-c}(\tau^\beta b_{-c})^{\frac{-\beta}{1-\beta}}\right]^{\frac{1-\beta}{\beta(1-\gamma)}-1} \left[b_c^{-\frac{\beta}{1-\beta}} - (\tau^\beta b_{-c})^{-\frac{\beta}{1-\beta}}\right]$$

.... equation (III-19)

In this equation, we can see that the sign of $\frac{\partial Q_c}{\partial K_c}$ is determined by the sign of the last term, $\left[b_c^{-\frac{\beta}{1-\beta}} - (\tau^\beta b_{-c})^{-\frac{\beta}{1-\beta}}\right]$. The sign of the last term changes according to the relative size between values b_c and $\tau^\beta b_{-c}$; we can see that the sign appears to be positive when the difference between the two is not significantly large, whereas the sign appears to be negative as the difference gets larger.

Similarly, the derivative of Q_{-c} with respect to K_c can be expressed as:

$$\frac{\partial Q_{-c}}{\partial K_c} = \left(\frac{\beta}{1+\beta}\right)^{\frac{1}{1-\gamma}} \frac{1-\beta}{\beta(1-\gamma)} \left[K_{-c} b_{-c}^{-\frac{\beta}{1-\beta}} + K_c(\tau^\beta b_c)^{\frac{-\beta}{1-\beta}}\right]^{\frac{1-\beta}{\beta(1-\gamma)}-1} \left[(\tau^\beta b_c)^{-\frac{\beta}{1-\beta}} - b_{-c}^{-\frac{\beta}{1-\beta}}\right]$$

.... equation (III-20)

In this equation, the sign of $\frac{\partial Q_{-c}}{\partial K_c}$ is determined by the sign of the last term $\left[b_c^{-\frac{\beta}{1-\beta}} - (\tau^\beta b_{-c})^{-\frac{\beta}{1-\beta}}\right]$; the signs of $\frac{\partial Q_c}{\partial K_c}$ and $\frac{\partial Q_{-c}}{\partial K_c}$ have broadly three combinations, but considering only the higher efficiency of country c, broadly two equilibria can be derived from the model.

Result 1: There are broadly two equilibria in this model, depending on the size of values b_c, b_{-c}, τ.

(Type 1: equilibrium between different countries)

When the gap between the labor market costs of the two countries is very large, or the trade cost is very small, the more capital invested in a country with more efficient labor market, the larger the total supply of differentiated goods in both countries.

Proof: When the condition of $b_c < \tau^{-\beta} b_{-c}$ *is satisfied,* $\frac{\partial Q_c}{\partial K_c} > 0$ *and* $\frac{\partial Q_{-c}}{\partial K_c} > 0$ *are satisfied.*

(Type 2: equilibrium between similar countries)

When the gap between the labor market costs of the two countries is not large, or the trade cost is very large, the more capital invested in the country c, the supply of differentiated goods in country c increases while the supply of differentiated goods in country $-c$ decreases.

Proof: When the condition of $\tau^{-\beta} b_{-c} \leq b_c < \tau^{\beta} b_{-c}$ *is satisfied,* $\frac{\partial Q_c}{\partial K_c} > 0$ *and* $\frac{\partial Q_{-c}}{\partial K_c} \leq 0$ *are satisfied.*

For the sake of convenience, we will refer to the two equilibria as (Type 1) and (Type 2). The condition of (Type 2) shows the result that we normally expect. When the capital of a particular country increases, the total supply of differentiated goods in the country increases, and the total supply of differentiated goods in the other country decreases. Capital goods should be supplied essentially to produce differentiated goods, and when the change of differentiated goods supply from imports is smaller than the change of differentiated goods from domestic supply, this equilibrium condition is satisfied.

(Type 1) shows a somewhat unusual result compared to (Type 2). It is in accordance with the intuition that the total differentiated goods supply in country c increases as the amount of capital in country c increases. However, the increase of the amount of capital in country c also increases the total differentiated goods supply in the other country.

This result is possible because the labor market cost (b_c) of country c is smaller than the labor market cost ($\tau^{-\beta}b_{-c}$) of the other country, considering the trade cost. Despite the existence of trade cost, the labor market cost of country c is much lower than those of the other country, therefore producing more differentiated goods by placing capital in country c increases the amount of differentiated goods supply of the other country as well.

What we find interesting in this result is that the size of trade cost also plays a very large role in determining the type of equilibrium. When the labor market cost of country c is much lower than that of the other country, the possibility of going to (Type 1) equilibrium is increased. The lower labor market cost means that the country is more efficient than the other country in terms of differentiated goods production, and therefore concentrating capital goods in a more efficient country leads to an increase of the total supply of differentiated goods in the economy. However, this mechanism works properly only when friction in the trading process of produced goods is moderately low enough. If the size of the trade cost is very large, the efficiency in production coming from the gap of labor market costs may be destroyed by the inefficiency in commodity trade, and therefore the equilibrium moves to (Type 2).

The conditions of the two equilibria show that it is important to consider the size of both labor market cost and trade cost at the same time, and that the patterns of tax competition may be very different in the two equilibria. For example, suppose that countries X and Y are in a trade relationship with Korea. Country X's labor cost is lower than Korea's, but the trade cost of the country is low due to geographical conditions or free trade agreements. The efficiency of the labor market in country Y is like that of Korea, but the trade cost of the country is larger than that of X in trading with Korea. Considering the situation in which Korea is in tax competition with X or Y and only the level of labor market efficiency, we can understand that there would be a big difference between the tax competition of Korea and country X, and that of Korea and country Y. However, considering the cost of trade at the same time, the pattern of the two tax competitions may be quite similar.

In the following, we will show how the patterns of the two equilibria appear through simulated results based on parameter values that satisfy the two equilibria.

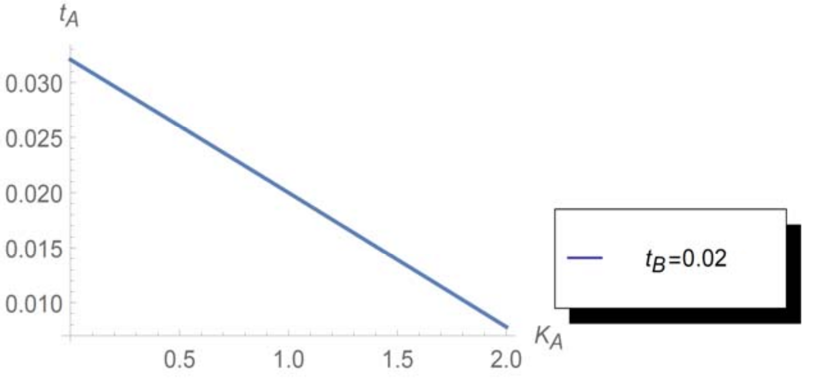
4 Tax Competition under Heterogeneous Labor Markets

In this section, we will look at how (Type 1) equilibrium appears, and then how country A and country B compete in (Type 1) equilibrium. The results of the simulations used below are all based on the following assumptions:

- The labor market of A is more efficient than that of B.
- The utility function $v(G)$ through public goods follows the form $50\sqrt{G}$.
- Assuming that β is 0.6, γ is 0.4, and τ is 1.2.
- The labor market cost of country B is given as 1.5 ($b_B = 1.5$).

First, let's look at the movement of endogenous variables according to the government's response, assuming that the labor market cost of country B is given. First, we can see that the total amount of capital flowing into country A decreases as the tax rate of country A increases. The figure below shows that if the government of country A levies a tax rate of more than 2%, when the other country sets the tax rate at 2%, there is a capital outflow ($K_A < 1$) in the country, whereas when the government of country A lowers the tax rate to less than 2%, there is a capital inflow ($K_A > 1$) in the country. We can see that this monotonic relationship between t_A and K_A is true for all parameter values as well, and using this, hereinafter, we will consider that when under t_B is given, the government of country A can decide the amount of capital inflow by controlling the tax rate.

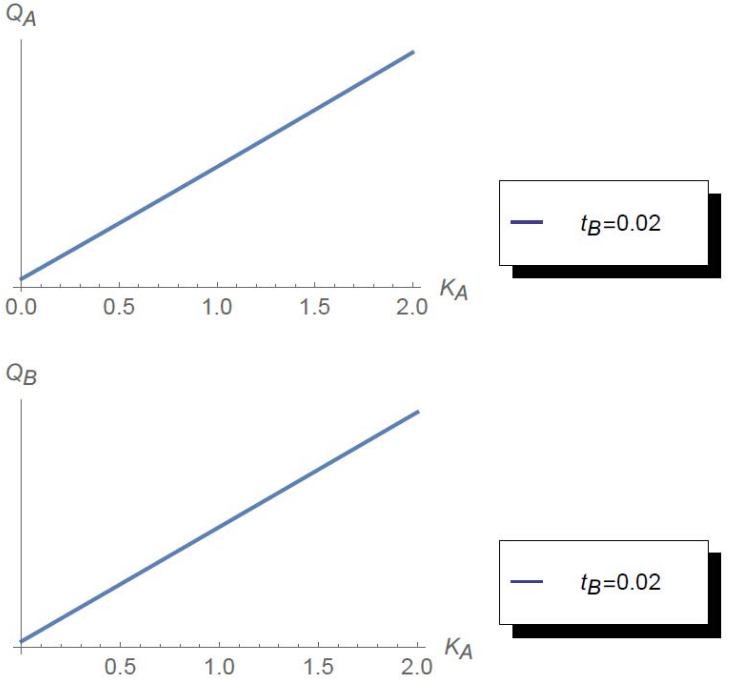
[Figure III-1] Tax Rate and In-/Outflow of Capital



Source: Made by the author

Now, let's consider the case where country A's government cuts the tax rate on capital to increase the amount of capital inflow to it. We can see that in (Type 1) equilibrium, the size of Q_A and Q_B increases as K_A increases according to result 1. The capital movement to country A, which is more efficient in production, leads to increase the supply of differentiated goods in line with the increase in domestic production from country A's point of view, and enables country B to expect an increase of the supply of differentiated goods in line with importing the differentiated goods, because in country A, the value of the labor market cost, which determines the efficiency of differentiated goods production, is low, and the size of the trade cost is not relatively large.

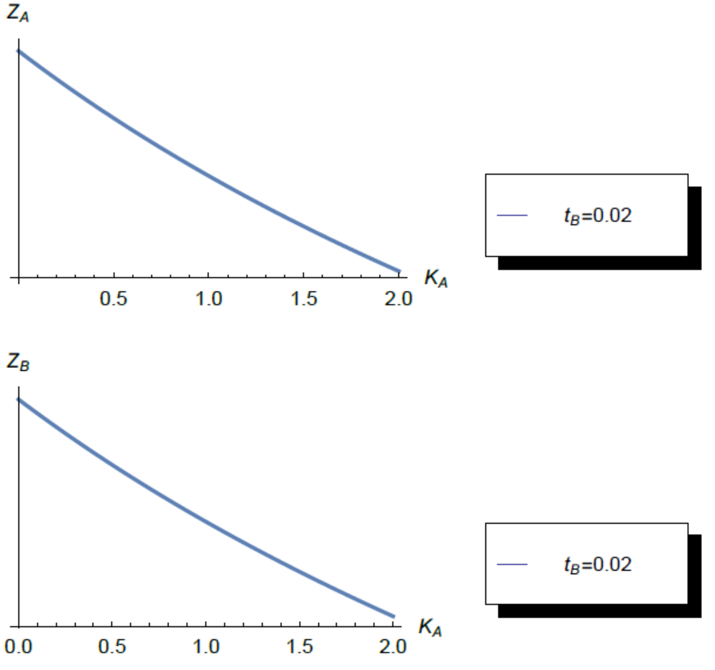
[Figure III-2] Capital Movement and Total Supply of Differentiated goods



Source: Made by the author

We can see that the other endogenous variables Z_A and Z_B decrease as the inflow to country A increases, because they are decreasing functions of Q_A and Q_B. Value Z_c represents the market return from the viewpoint of each firm producing differentiated goods in country c; the market return of each firm decreases as value K_A increases, because the total supply of differentiated goods in both countries increases.

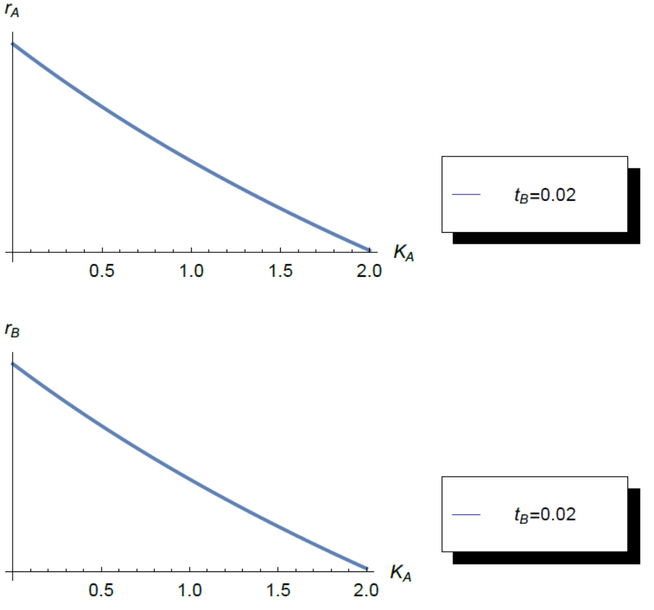
[Figure III-3] Capital Movement and Market Return



Source: Made by the author

We can easily understand that r_A and r_B, which are defined as the cost of lending one unit of capital goods, will also show a similar pattern to the market return curve. This is due to the characteristic that the profit of the differentiated goods producer is converged to zero by the assumption of a myriad of potential entrepreneurs. Therefore, the decline in the return of a firm directly implies a reduction in the price of capital goods traded in the market. You can see the relationship in the figure below.

[Figure III-4] **Movement of Capital and Return on Capital**

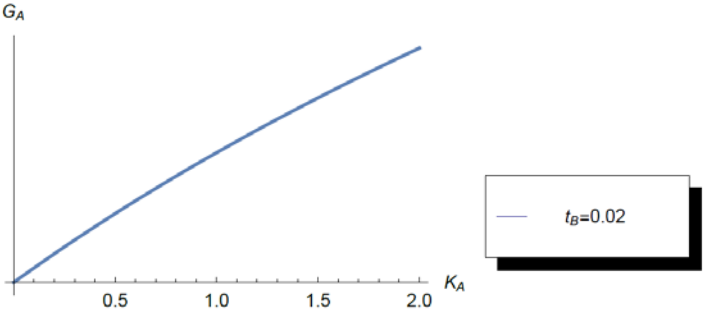


Source: Made by the author

The above graphs show how the endogenous variables in (Type 1) equilibrium respond to the policy of country A's government. The above simulation results can be understood as the results when country B's government fixes the tax rate at the level of 2%. Country A's government will determine the amount of capital goods that maximizes the indirect utility function of its country under the given tax rate level of country B's government, and then it will levy a corresponding tax rate on capital, and based on the tax revenue earned from it, it will implement a policy of supplying public goods.

The figure below shows the correlation between capital movements and the amount of public goods supply in country A. We can see that the supply of public goods also increases as the inflow of the amount of capital goods to country A increases.

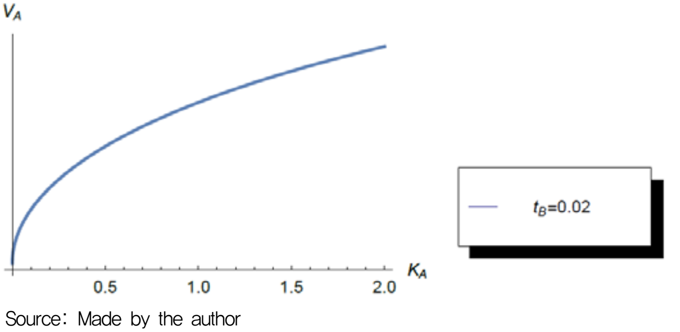
[Figure III-5] **Capital Movement and Supply of Public Goods**



Source: Made by the author

Next, let's examine the indirect utility function of country A in line with capital movements. The figure below shows how the indirect utility function of country A changes in accordance with the amount of capital goods. We can see that value V_A continuously increases in the $K_A \in [0, 2]$ section. Country A's government will try to promote the inflow of capital by lowering the tax rate as far as possible, because the social welfare of country A will be maximized at the point of $K_A = 2$. In other words, country A's government lowers the capital tax rate to maximize capital inflow, and based on this, it can maximize social welfare by supplying public goods.

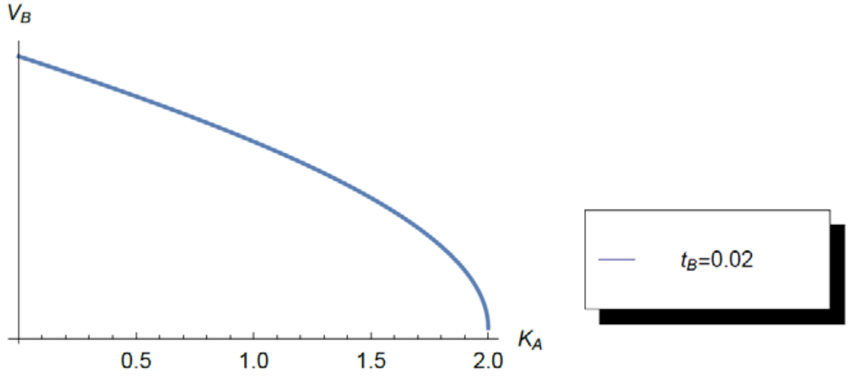
[Figure III-6] **Capital Movement and Social Welfare (Country A)**



Source: Made by the author

Whether the strategy of country A's government is possible or not depends on the response of country B's government to capital outflow. The reason is that country B's government will also change the tax rate depending on the level of social welfare of country B relevant to capital movement. The figure below shows the change in social welfare of country B according to the policy of country A's government, with the tax rate of country B fixed at the level of 2%. You can see that the social welfare of country B decreases as capital flows from country B to country A.

[Figure III-7] **Capital Movement and Social Welfare (Country B)**



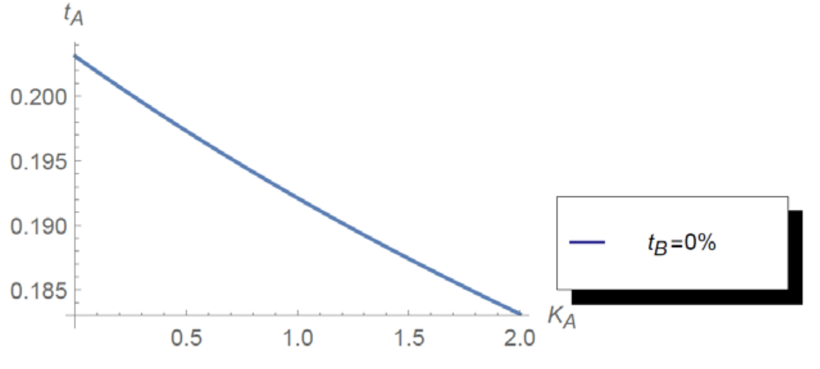
Source: Made by the author

Considering both results together, we can see that both country A's government and country B's government have incentives to attract more capital by lowering the capital tax rate.

In this case, we can understand intuitively that equilibrium will be determined at a level favorable to country A's government. The reason is that we assumed that the circumstances of the two countries are symmetrical, and that country A has more efficient labor market. Thus, country A's government has a better position in tax competition than country B's.

Deriving the actual equilibrium, we can confirm that it is $K_A = 2$, which means that country B does not match country A in terms of tax competition. The graph below shows the relationship between the tax rate of country A and the amount of capital inflow when country B sets the tax rate on capital to 0%. Although country B has lowered the tax rate to the utmost, country A can attract all capital to it even at a tax rate higher than 18%. In other words, even though country B's government chooses any tax rate, country A's government can maximize its social welfare by bringing all the capital into it.

[Figure III-8] **Tax Rate and In-/Outflow of Capital ($t_B = 0\%$)**



Source: Made by the author

5 Tax Competition under Homogeneous Labor Markets

Let's examine the case where the difference in labor market efficiency between the two countries is not large. The representative case of this equilibrium is the symmetrical equilibrium where the labor market efficiency of the two countries is completely homogeneous. The first condition to maximize the social welfare of the two countries in a symmetric equilibrium is as follows:

$$-r_c\widehat{K_c}+(1-t_c)\frac{\partial r_c}{\partial t_c}\widehat{K_c}+(1-\gamma)Q_c^{\gamma-1}\frac{\partial Q_c}{\partial t_c}+\frac{\partial v_c}{\partial G_c}\left[r_cK_c+t_cK_c\frac{\partial r_c}{\partial t_c}+t_cr_c\frac{\partial K_c}{\partial t_c}\right]=0$$

…………………………………………………………………… equation (III-21)

This condition can be rewritten as $\frac{\partial Q_c}{\partial t_c}$ and $\frac{\partial r_c}{\partial t_c}$ as a function of $\frac{\partial K_c}{\partial t_c}$ using the relationship between the variables derived above. In addition, by applying the assumption that the labor market efficiency of the two countries is the same, the following can be derived.

$$\frac{\partial Q_C}{\partial t_C} = \Phi \frac{\partial K_C}{\partial t_C} \quad \cdots\cdots \text{equation (III-22)}$$

$$\frac{\partial Z_C}{\partial t_C} = \Gamma \frac{\partial Q_C}{\partial t_C} \quad \cdots\cdots \text{equation (III-23)}$$

$$\frac{\partial r_C}{\partial t_C} = \Psi \frac{\partial Z_C}{\partial t_C} \quad \cdots\cdots \text{equation (III-24)}$$

where, Φ, Γ, and Ψ are respectively as follows.

$$\Phi = \left[\frac{\beta}{1+\beta}\right]^{\frac{1}{1-\gamma}} \frac{1-\beta}{\beta(1-\gamma)} \left[Kb^{-\frac{\beta}{1-\beta}}\left(1-\tau^{-\frac{\beta^2}{1-\beta}}\right)\right]^{\frac{1-\beta}{\beta(1-\gamma)}-1} b^{-\frac{\beta}{1-\beta}}\left(1-\tau^{-\frac{\beta^2}{1-\beta}}\right)$$

$$\cdots\cdots \text{equation (III-25)}$$

$$\Gamma = -\frac{\beta-\gamma}{1-\beta} Q^{-\frac{\beta-\gamma}{1-\beta}-1}\left(1-\tau^{-\frac{\beta}{1-\beta}}\right) \quad \cdots\cdots \text{equation (III-26)}$$

$$\Psi = \frac{1-\beta}{\beta}\left(\frac{\beta}{b(1+\beta)}\right)^{\frac{1}{1-\beta}} b \quad \cdots\cdots \text{equation (III-27)}$$

Therefore, the primary condition of maximization can be rewritten as follow.

$$-rK + (1-t_C)K\Phi\Gamma\Psi\frac{\partial K_C}{\partial t_C} + (1-\gamma)Q_C^{\gamma-1}\Phi\frac{\partial K_C}{\partial t_C} + \left[rK + t_c K\Phi\Gamma\Psi\frac{\partial K_C}{\partial t_C} + t_c r\frac{\partial K_C}{\partial t_C}\right]\frac{\partial v_C}{\partial G_C} = 0$$

$$\cdots\cdots \text{equation (III-28)}$$

Using the equation, we can easily understand how the presence of cross-country mobility of capital affects the tax rate in equilibrium and the amount of public goods supply.

A. Benchmark: When Capital Movements Between Countries Are not Possible

First, let's consider a benchmark case where capital movements between countries are not possible. In this case, even though the tax rate changes, the amount of capital invested in one country does not change. In other words, because $\frac{\partial K_C}{\partial t_C} = 0$, the primary condition of maximization, which is the level of public goods supply to maximize welfare in a closed economy, is as follows.

$$\frac{\partial v_C}{\partial G_C} = 1 \quad \text{equation (III-29)}$$

Furthermore, when two countries decide together with t_A and t_B to maximize $V_A + V_B$ by tax coordination, the following results can be derived.

Result 2. When capital movements between countries are not possible, the supply level of public goods is determined by the following equation, which is the level of public goods supply that maximizes the welfare of both countries by the tax cooperation of symmetrical two countries.

$$\frac{\partial v_C}{\partial G_C} = 1 \quad \text{equation (III-30)}$$

Proof. When both countries are symmetrical in all respects, the optimal tax rate is the same. That is, $t_A = t_B$ *is established. Capital is invested equally in both countries, and returns on investment are equal, because all the conditions are the same, there is no capital movement when we change the tax rates of both countries equally. In the absence of capital movement, optimal public goods supply is determined by the equation derived above.*

This result shows that the sum of the welfare of the two countries is maximized in the absence of capital movement, and that the welfare level may be lowered by capital mobility. In addition, we can understand that in the absence of capital movement, labor market incompleteness and the cost of international trade have no effect on the level of optimal supply of public goods.

B. When Capital Movements Between Countries Are Possible

When capital movements between countries are possible, if a government raises the tax rate to increase tax revenue, the transfer of capital may, on the contrary, lead to a decline in tax revenue. Therefore, the degree of a government's freedom to change the tax rate is lower than in the absence of capital movement, which may lead to a decrease in public goods supply.

The impact of capital movements on the taxing power of each country works broadly through two channels. First, there is pressure to reduce tax revenue due to the existence of trade costs. Under the circumstances where a government consider the fact that levying taxes can lead to capital outflow to foreign countries, the effects of consumption of one unit of domestic production and consumption of one unit of imports on social welfare may be different.

The cost of higher tax rate works through the channel of decreasing the utility of domestic consumers. When capital moves to the other country and produces differentiated goods, the demand by domestic consumers for such goods should be met through imports from the other country. For the amount of goods produced with the same capital amount, the amount through imports is smaller than that through domestic production, unless it is assumed that there is no trade. This can be seen as an additional cost of increasing the capital tax rate, because it lowers the utility of domestic consumers. This means that the level of public goods that maximize social welfare is reduced to depart from $\frac{\partial v_c}{\partial G_c}=1$, the condition of public goods supply when capital movement is impossible.

Next, there is pressure to reduce tax revenue due to the movement of the tax base. Because of the possibility of capital movements, each government should consider the capital that flows out to foreign countries when levying taxes. As the tax rate increases, capital is moved to find a lower tax rate, and it reduces tax bases because capital is assumed to be free to move. When the increase in tax revenue by increasing the tax rate is not greater than the decrease in tax revenue due to the movement of tax bases, this effect leads to a decrease in the supply of public goods.

To see this effect more specifically, let's consider the case where there is no trade cost at all. Because there is no trade cost, the cost of supplying to the domestic market is the same as that of supplying to the overseas market, and firms can supply the desired amount of goods to the market they want, regardless of the country where they are located. Therefore, return on investment r is not affected by the location of the capital. That is, even though capital moves, the return on investment r is not affected. The following results can be obtained, because the results imply that the values of Φ and Γ become zero in the above formula.

Result 3. When the movement of capital is allowed and $\tau = 1$, public goods are under-supplied.

Proof. When $\tau = 1$, Φ and Γ become zero. Therefore, the first condition of maximization is as follows.

$$rK = \left[rK + t_C r \frac{\partial K_C}{\partial t_C} \right] \frac{\partial v_C}{\partial G_C} \quad \cdots\cdots \text{equation (III-31)}$$

In the above equation, $t_C r \frac{\partial K_C}{\partial G_C}$ is a negative number. Thus, $\frac{\partial v_C}{\partial G_C}$ is greater than 1.

Considering that there is no trade cost from the consumer's point of view, it implies that the position of a firm has no influence on the consumption of differentiated goods produced by one unit of capital. Therefore, production and consumption in the private sector are not affected by the tax rate. On the other hand, an increase in the tax rate immediately affects the net rate of return $(1-t)r$, leads to a capital outflow, and therefore makes tax bases immediately decrease, which leads to a decrease in the supply of public goods.

We have summarized above that in the situation where capital movement is free, when a government raises the tax rate, the taxing ability of the government may be reduced, because a decrease in the amount of demand for differentiated goods may make the welfare level lower, and taxable objects also decrease. As a result, the taxing power of each government is reduced, and the public goods are under-supplied compared with the cases of tax cooperation.

To confirm this basic logic in more general cases, we will analyze the strategic interactions between governments by applying concrete functions and numerical values, and will examine how the equilibrium of the model changes when parameter values change.

C. Choice of Each Government

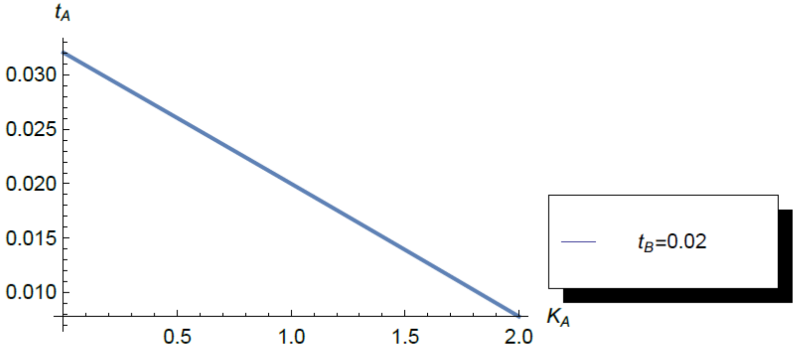
Let's examine graphs to see how the endogenous variables in equilibrium change according to the tax rate choice of government A. The assumptions about the parameter values used in the simulation of (Type 1) equilibrium remain the same here. That is, all simulation results below are based on the assumption of difference.

- The labor market efficiency of both countries is the same.[8)]
- The utility function $v(G)$ through the public goods follows the form of $50\sqrt{G}$.
- Assuming that β is 0.6, γ is 0.4, and τ is 1.2.
- The labor market cost of country B is given as 1.5 ($b_A = b_B = 1.5$)

8) Even in the condition $\tau^{-\beta} b_B \leq b_A < \tau^{\beta} b_B$ that is satisfied by relaxing this assumption, the qualitative results of the simulation are the same.

As in the previous case, because the tax rate and the capital amount of a particular country has a one-to-one negative relationship, we will explain hereafter the equilibrium based on the recognition that country A's government can directly control the amount of capital of country A by changing the tax rate.

[Figure III-9] **Tax rate and In-/Outflow of Capital (Type 2)**

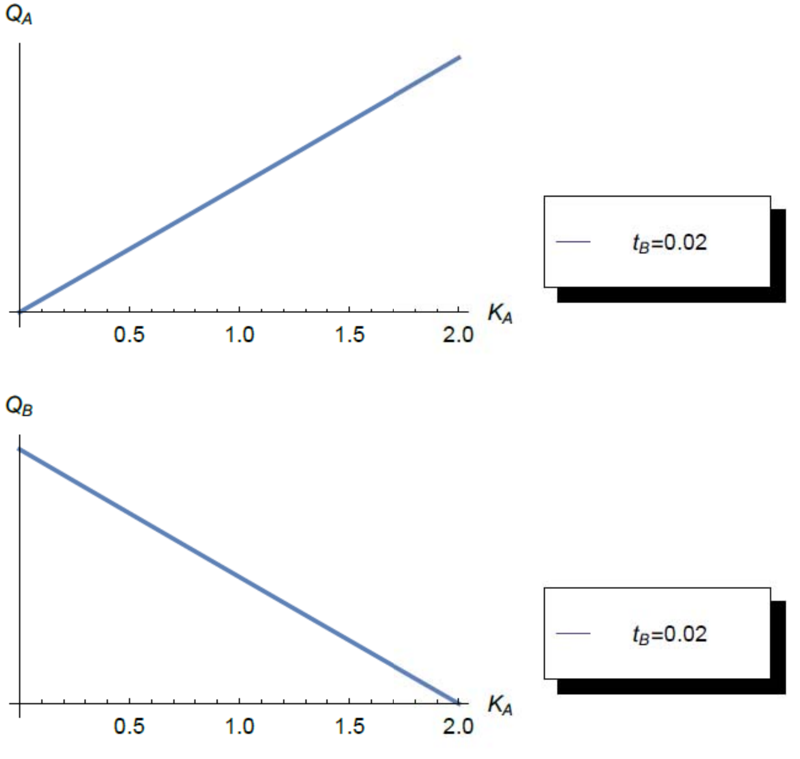


Source: Made by the author

First, let us examine how the total amount of differentiated goods in the two countries changes when capital moves to country A. We can see that, in contrast to (Type 1) equilibrium, in (Type 2) equilibrium, as value K_A increases, value Q_A increases while value Q_B decreases. This corresponds to the basic equilibrium condition summarized in result 1. In (Type 1) equilibrium, the concentration of capital into the country with efficient labor marke resulted in an increase in the total supply of differentiated goods in both countries, because the labor market efficiency of country A was much higher than that of country B. On the other hand, in (Type 2) equilibrium, the concentration of capital in country A increases the total supply of differentiated goods in country A, but that leads to a decrease in the supply of differentiated goods in country B, because the gap in labor market efficiency between country A and country B is not large.

These results are more likely to occur in the presence of considerable trade costs; when the labor market efficiencies of the two countries are exactly the same as in the simulation situation, if there is even a small trade cost, capital outflow to the other country leads to a decrease in the supply of differentiated goods in the home country. We can understand that the increase in differentiated goods supply due to production efficiency is offset by trade inefficiency.

[Figure III-10] Capital Movement and Total Supply of Differentiated Goods



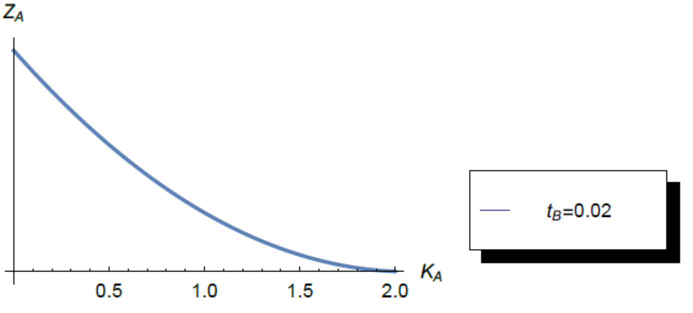
Source: Made by the author

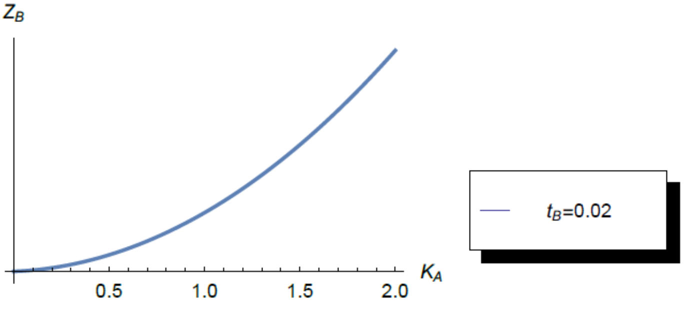
Second, let's look at the market returns that are recognized by each firm engaged in differentiated goods production. Z_c was defined above as:

$$Z_c = Q_c^{-\frac{\beta-\gamma}{1-\beta}} + \tau^{-\frac{\beta}{1-\beta}} Q_{-c}^{-\frac{\beta-\gamma}{1-\beta}} \quad \text{equation (III-33)}$$

In this equation, Z_c is a decreasing function of Q_c and Q_{-c}, and we can understand that value Q_{-c} is adjusted to trade cost $\tau(>1)$ so that the change of value Z_c can occur due to the change of value Q_c in the situation where τ is large enough. That is, we can see that as Q_c increases, Z_c decreases while Z_{-c} increases.

[Figure III-11] **Capital Movement and Market Return (Type 2)**

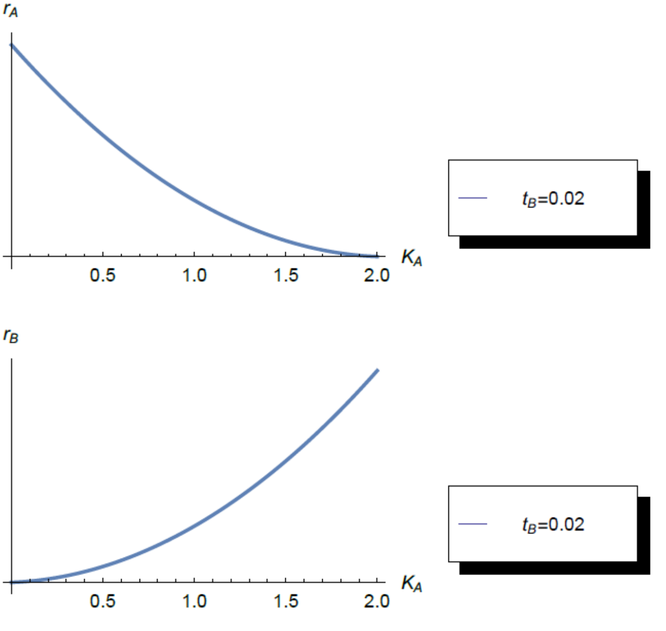




With capital concentration in country A, the aggregate supply of differentiated goods in country A increases, while the total supply of differentiated goods in country B decreases. Even though the differentiated goods productivities of both countries are exactly the same, due to the existence of trade costs, the increase in the total supply in country A is greater than the decrease in country B, and a firm located in country A encounters increased competition in the market. Likewise, capital movements to country A will have an effect of lowering market competition of each differentiated goods producer located in country B, and increasing market returns.

Such changes in market returns directly affect capital returns. In the situation where there are potentially infinite differentiated goods producers in waiting, a positive profit triggers competition for one unit of capital. Therefore, as the market return increases, the return on capital also increases.

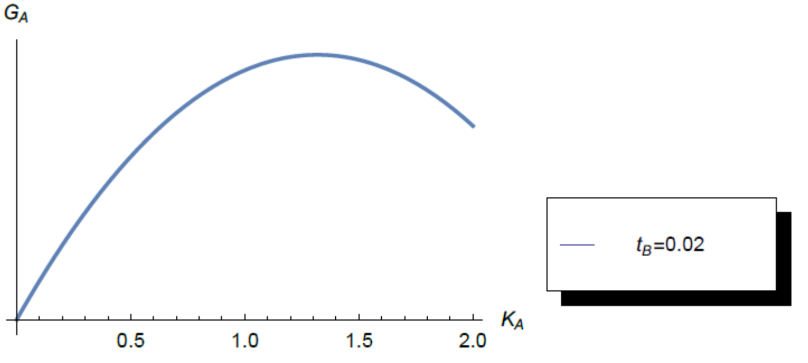
[Figure III-12] **Capital Movement and Return on Capital (Type 2)**



Source: Made by the author

Third, let us examine the effect of capital movements on the supply of public goods according to the change in a tax rate. The figure below shows that as value K_A increases, the supply of public goods increases, and when the amount of capital is beyond a certain level, the supply of public goods decreases again. Assuming that all tax revenues from capital taxation are used to supply public goods, we can understand that tax revenue decreases when the amount of capital is beyond a certain level. The inflow of capital to the domestic market is an increase in tax revenue, which is positive for the increase in tax revenue, but because the tax rate should be lowered for capital inflow, which is a negative factor in the increase in tax revenue. Therefore, if a tax rate is lowered beyond a certain level, we can see that the tax revenue decreases despite the increase in the tax base.

[Figure III-13] **Capital Movement and Supply of Public Goods (Type 2)**

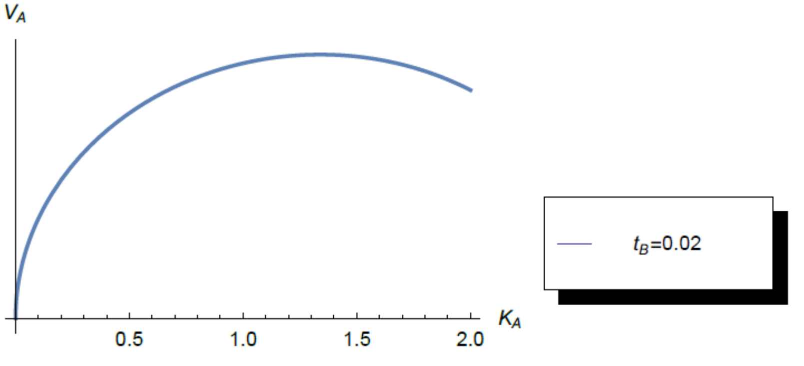


Source: Made by the author

Considering that public goods consumption is a major axis of social welfare, the relationship between tax rate and public goods supply implies that the value for the optimal amount of capital selected by each government may be less than 2 even in tax competition. In the (Type 1) equilibrium examined above, there was an incentive for the country where the labor market is much more efficient to minimize the tax rate on capital as much as possible to promote the inflow of all capital. That is, the tax rates set by the two countries in equilibrium will have a corner solution. On the other hand, when the labor market efficiencies of the two countries do not differ greatly, there may be an inner solution in which the tax rates are set at a level where both countries have a certain level of capital goods.

This is described well by the following figure, which shows the relationship between capital movements and social welfare level. The change of social welfare function according to the amount of capital is similar to the relationship between the amount of capital and the supply of public goods. In the section of $0 < K_A < 2$, there may be an equilibrium value K^* that maximizes the social welfare of country A, and thus an inner solution occurs.

[Figure III-14] **Capital Movement and Social Welfare (Type 2)**



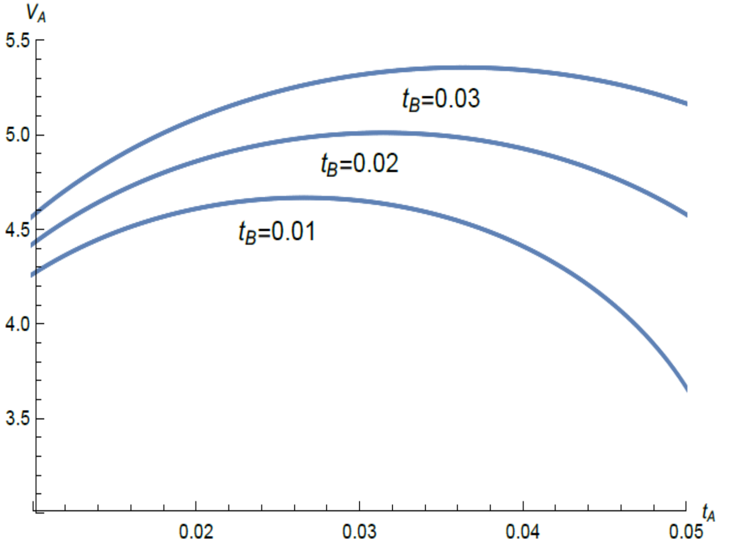
Source: Made by the author

All of the simulation results above should be understood as a change in endogenous variables according to the tax rate change of the other country with the fixed tax rate of one country. In actual tax competition, the tax rates of the governments of both countries change according to the tax rate of the other country's government. The result of this strategic interaction constitutes the Nash equilibrium of this model. In the following, we will look at how strategic interactions between countries would work, and what a Nash equilibrium of the model, which is formed as a result, would be.

D. Strategic Interaction

The government of each country accepts the tax rate of the other country as a given, and decides on a tax rate that maximizes the objective function. The figure below shows how the social welfare of country A changes when the tax rate of country B changes. First, we can see that domestic production of differentiated goods as well as taxable objects increases, and a higher welfare level can be achieved because capital flows into country A as the tax rate of country B increases. In addition, we can see that the objective function of country A is maximized, or that the point of maximization moves to right side little by little according to the increase of the tax rate of country B.

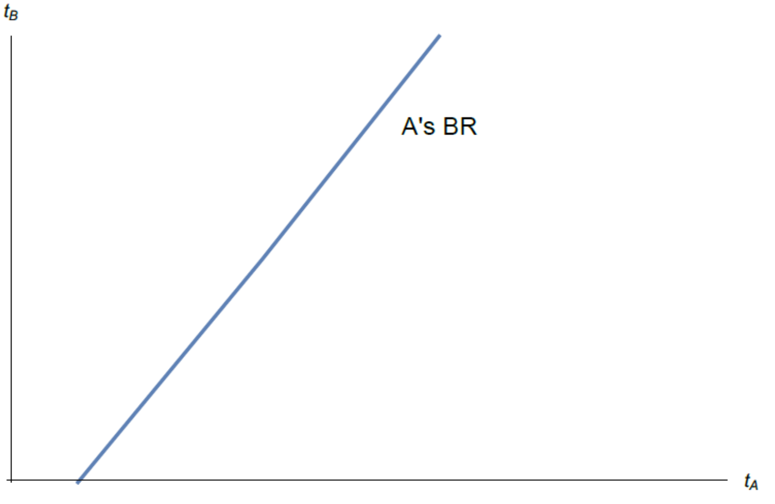
[Figure III-15] **Country A's Optimal Tax Rate Change in accordance with Country B's Tax Rate Change**



Source: Made by the author

The increase in country A's optimal tax rate as the increase of country B's tax rate means that there are strategic complementarities in the tax rate-decision game between the two governments. That is, it is an optimal game where one party increases its tax rate as the other party increases its tax rate, and one party lowers its tax rate as the other party lowers its tax rate. In the strategic complementarities game, the best response curve for each player is upward. The figure below expresses the best response curve for country A. As mentioned above, we can see that the optimal tax rate of country A also increases as the tax rate of country B increases.

[Figure III-16] **Best Response Curve for Country A**

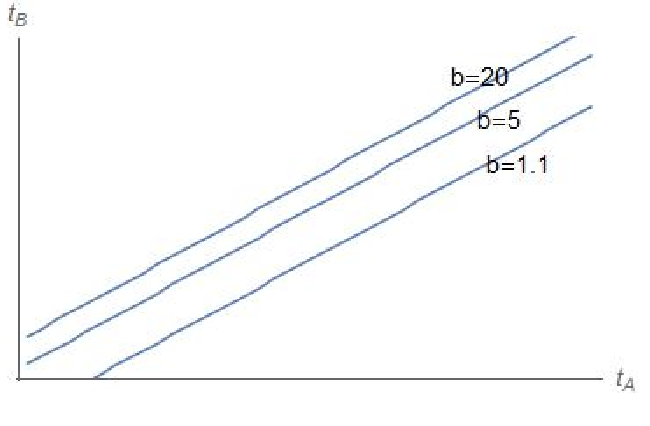


Source: Made by the author

Next, let's examine how the best response curve of country A changes in accordance with changes in labor market efficiency. Considering that both countries are symmetric, we will see how it affects the decision on optimal tax rate when the two countries' labor market efficiencies improve or deteriorate at the same time.

The figure below shows changes in the best response curve for country A when the labor market efficiencies of both countries increase. In this figure, we can see that the best response tax rate of country A rises in the equilibrium, but not in the equilibrium where the labor market efficiency is the highest. When the labor market becomes more inefficient, the production efficiency of differentiated goods producers is lowered. If there is no trade cost, the deterioration of symmetric labor market efficiency will not affect a firm's position, but because there is a trade cost, even the deterioration of efficiency in a symmetric labor market causes an effect that lowers the incentive for moving capital to a foreign country. Therefore, the taxation autonomy of the two governments is strengthened, and the best response curve can be placed at the top.

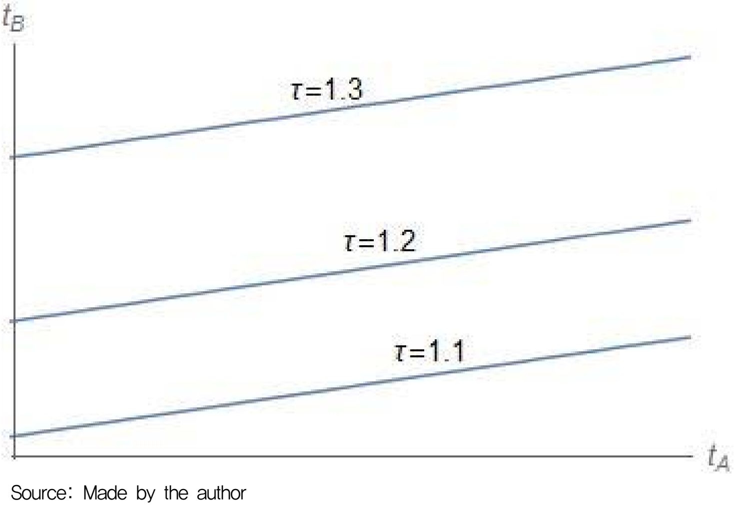
[Figure III-17] Changes in Response Curves in Accordance with Changes in Labor Market Efficiency



Source: Made by the author

Finally, let's examine how the best response curve changes as the size of export cost changes. The figure below expresses the best response curve for each export cost. The best response curve for all export costs is still upward, but we can see that the optimal tax rate increases as the export cost increases. This implies that the increase in export costs causes an effect that lowers the incentive for moving capital to a foreign country. As the export cost increases, the domestic market becomes more important than the export market, and in terms of capital, it becomes important to know which country it produces. Capital tends to spread evenly between the two countries, which weakens the response to the tax rate, because production in a country with a small number of firms is the way to get higher profits. Therefore, the taxing powers of the two governments are strengthened as the cost of trade increases.

[Figure III-18] **Best Response Curve in Accordance with Change in Export Cost**



Source: Made by the author

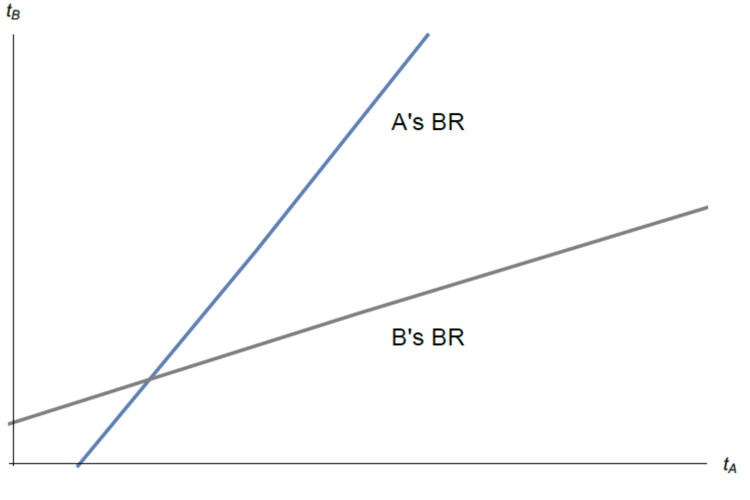
E. Nash Equilibrium

If the same task is performed for country B, the change in the tax rate of country B can be plotted according to the setting of the tax rate of country A. Drawing two best response curves together can find the Nash equilibrium at the intersection of the two lines. The figure below shows the best response curve for country A and the best response curve for country B together. The Nash equilibrium of this economy can be found at the intersection of the best response curves of the two countries.

This figure shows that equilibrium is formed at $t_A > 0$ and $t_B > 0$, unless there is a big difference between the labor market efficiencies of the two countries. It shows well that the tax rate does not fall in a race to the bottom unless the difference in the efficiency of differentiated goods production between the two countries is large, even in tax competition.

The Nash equilibrium also changes as value $b = b_A = b_B$ and trade cost rise. As we have seen above, the best response curves of both countries move in a direction away from the origin, as value b increases. Therefore, a rise in labor market cost leads to an increase in the equilibrium tax rate. The new Nash equilibrium will be formed at a higher equilibrium tax rate because the rise in trade cost also has the same effect as the increase in value b.

[Figure III-19] **Best Response Curves of the Two Countries**

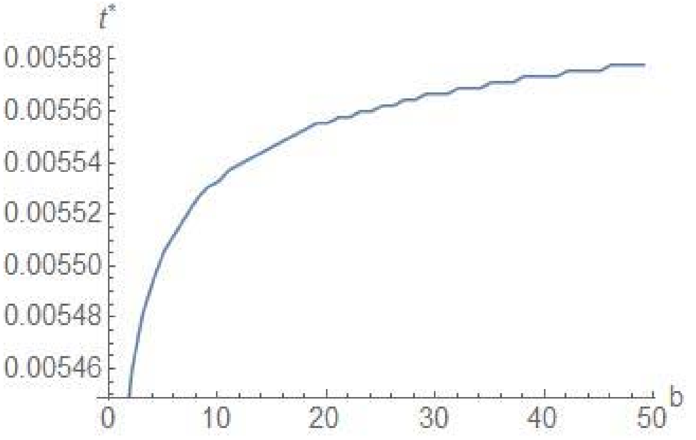


Source: Made by the author

The following figures illustrate the explanations above well. [Figure III-20] shows the relationship between labor market inefficiency and the Nash equilibrium tax rate when the trade cost is 1.1. As discussed earlier, the equilibrium tax rate rises as b increases, but the rate of increase decreases. The reason is that if b is too high, the market for differentiated goods shrinks, and the influence on the optimal tax rate decreases.

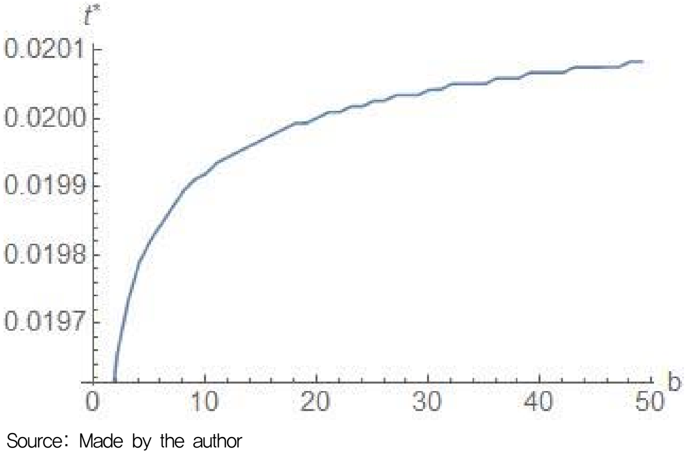
[Figure III-21] to [Figure III-23] are the same graphs as [Figure III-20] assuming different export costs. The pattern of an upward-sloping curve is the same for all graphs. The noticeable part is that the equilibrium tax rate raises as the export cost rises, which was predicted earlier from the analysis of the best response curve.

[Figure III-20] **Equilibrium Tax Rate ($\tau=1.1$)**



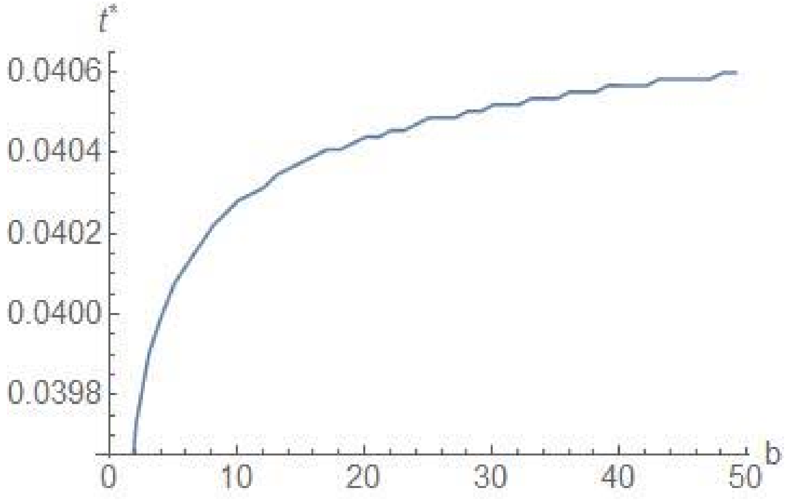
Source: Made by the author

[Figure III-21] **Equilibrium Tax Rate ($\tau=1.2$)**



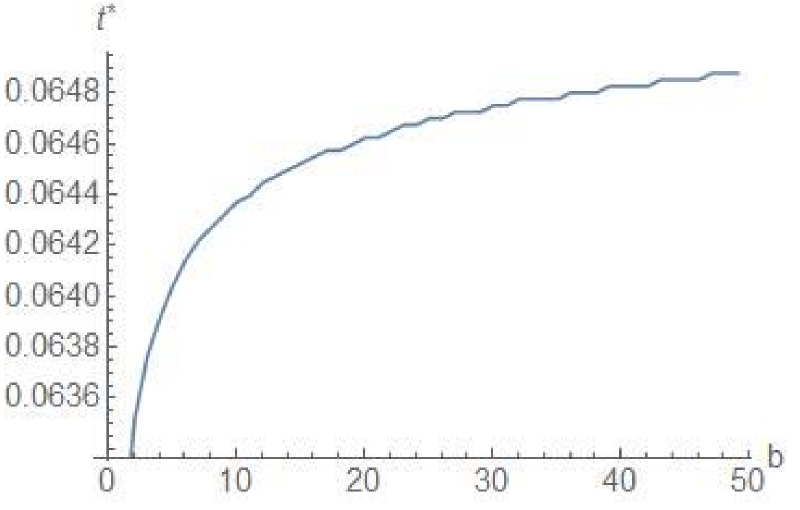
Source: Made by the author

[Figure III-22] **Equilibrium Tax Rate ($\tau = 1.3$)**



Source: Made by the author

[Figure III-23] **Equilibrium Tax Rate ($\tau = 1.4$)**



Source: Made by the author

Ⅳ

Conclusion

In the section above, we analyzed theoretically how the gap of labor market efficiency and the size of trade cost of the two countries affect the pattern of tax competition, assuming an economy in which there are two countries and two sectors.

The model clearly shows that the relative size of the labor market efficiency of the two countries may significantly change the pattern of tax competition. We confirmed that relative labor market efficiency can have the advantage of promoting capital inflow despite a higher level capital tax rate compared to other countries. We also confirmed that even if the labor market efficiency gap is not large, an increase in the symmetric labor market cost will strengthen the taxing powers of the two governments.

Trade costs reduce the difference in the production efficiencies that are originated from differences in labor market efficiency. As the trade cost increases, the efficiency of production is offset by the inefficiency of trade, which lowers the relative importance of labor market efficiency. Therefore, diminishing trade costs weaken the taxing power of a government, and increasing trade costs strengthen the taxing power of a government.

These results show well the interaction of labor market efficiency and trade cost, which has not received much attention in previous studies. In analyzing the effects of labor market inefficiency on tax competition, previous studies have often focused on the conclusion that symmetrical increases or decreases in labor market inefficiency mitigate or increase tax competition. However, in this study, the trade cost and the labor market efficiency are substitutes in tax competition context, and as a result, the pattern of tax competition in the model is explained in more specific and realistic way than in previous studies. The results of this study contrasts with Egger and Seidel (2011) which also considered trade cost and labor market efficiencies in the tax competition context.

The theoretical model developed above suggests the following policy implications in deciding a corporate tax rate.

First, a simple comparison of corporate tax rates by country is hardly meaningful in making a decision on a proper corporate tax rate. If there are other economic strengths that can attract capital inflows, a higher corporate tax rate can be maintained.

Second, it suggests that there is substitutability between the capital tax rate level and labor market efficiency. In Korea, various policies have been introduced to improve labor market efficiency. As a result, we might expect to have more efficient labor market in the long run. If this is the case, it can lower the pressure on capital outflow due to the increase of the corporate tax rate.

Finally, we can see that there is a reverse relationship between the level of trade openness and the tax sovereignty of a country. The trade cost has been decreased as bilateral or multilateral free trade agreements continue to be enacted. Although the decrease in the trade cost allows an increase of the economic benefits through freer trade, it weakens the taxing sovereignty as the degree of tax competition increases.

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