Secession and Distribution of Natural Resources

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Abstract

This study uses a simple theoretical model to present analyses of a secession and the distribution interests of natural resources. As Krugman [7], Ottaviano, Tabuchi, and Thisse [9], and other core-periphery models demonstrate, a decrease in population presents some difficulties for secession in terms of variety, economies of scale, and home market effects. Consequently, a decrease in population taking place in the minor region suppresses incentives for minor region to be independent from the home country. Similarly to the minor region, the major region might also sustain damage because of declining population with secession. Secondly, the minor region can presumably attract interest in natural resources located non-uniformly in particular regions, which increase the incentive of a minor region to secede from the home country. These effects have a mutual trade off relation. A minor region will choose secession from the home country or not after considering this trade off relation.

Ⅰ Introduction

This paper presents analyses of conditions in which regions have an incentive to secede from the home country. A simple setting is used for theoretical analysis of the relation between secession and the allocation interest of natural resources. Many regions have divided and separated repeatedly throughout human history. The Roman Empire and the Frank Kingdom divided respectively into the Eastern and Western Roman Empires and into France, Germany and Italy. More recently, East Timor Republic seceded from Portugal. Moreover, Scotland, a part of Ukraine, and Catalunya state are seceding respectively from the United Kingdom, Ukraine, and Spain. In stark contrast, integration has occurred among countries as

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well, as in the case of West Germany and East Germany. In terms of economic integration, European countries have integrated economically to the EU. In Japan, many municipalities have been integrated since the 21st century.

Integration and secession are attributable to reasons of many kinds that include policy, culture, and religion. Secession and independence issues are sometimes caused by the allocation of natural resource interests. In fact, natural resources have always been a cause of conflict among countries. Consequently, these regions consider secession from a home country : rights of natural resources such as oil, gas, and minerals have been important factors. The government has an incentive to secede from the home country if any region is able to occupy the interests of natural resources after secession. For instance, Collier and Hoeffler [4] [5] demonstrate that resource dependence exerts a strong curvilinear effect on the onset and duration of war or conflict. Brunnschweiler and Bulte [3] examine the effects of resource abundance on the onset of conflict with empirical analysis. They show that resource abundance lowers the risk of conflict via indirect income effects, although resource dependence is not specifically addressed. These empirical results suggest that natural resources affect the behavior of secession or independence, although no discussion has been reported about the importance of these empirical studies.

Many earlier theoretical studies of regional secession or integration have analyzed this issue. Some studies present consideration of how borders or relative sizes of countries are determined endogenously. In political economics, a pioneer study addressing this issue is Alesina and Spolaore [1]. After they consider how the number of countries is determined endogenously, they derive the stability condition of the equilibrium number of countries. Furthermore, they consider that the population is a key factor determining the number of countries ; the equilibrium number of countries is larger than that controlled by a social planner who maximizes the average utility of all countries. Bolton and Roland [2] also construct a model of national integration and disintegration. They introduce a voting model into the decision to secede and its related mechanisms. Moreover, they show that secession occurs in equilibrium when income distributions vary across regions and when the efficiency gains from unification are small. In such cases nobody has an incentive to secede when all production factors are mobile among countries. Ohno [8] introduces natural resources, which are considered as conflict-causing among countries by Collier and Hoeffler [4] and [5], into the political economics models of Alesina and Spolaore [1] or Bolton and Roland [2]. In addition, they analyze the taxation policy of major regions to prevent the secession of a minor region. However, although Ohno [8] considers population agglomeration or economies of scale, he specifies the effects of agglomeration as an exogenously given function and does not explain the microeconomic foundation clearly.

However, in spatial economics, Krugman [7], Ottaviano, Tabuchi, and Thisse [9], Tabuchi [10], and so on contribute to construction of the model, which clarifies how cities occur or population and firms agglomerate in a particular region. These studies apply increasing returns of scale to monopolistic competition to regional models and clarify the mechanisms of regional agglomeration and dispersion. They show that home market effects result in regional agglomeration and demonstrate that the population size plays an important role in regional agglomeration. Although these studies contribute to explaining economic integration in cases such as that of the EU, they ignore the political aspects of determining borders between countries. Although Takatsuka, Zeng, and Zhao [11] analyze the effects of natural resources on agglomeration or dispersion under a core-periphery model, they do not incorporate the endogenous determination of borders among them.

We extend a model including natural resources similar to that of Ohno [8] or Takatsuka, Zeng, and Zhao [11] by combination with a political economics model to incorporate secession. Results show that the government of a minor region does not consider secession from the home country when the interests of natural resources in a minor region are not so large.

The remainder of the article is organized as explained below. Section 2 introduces the integrated economy as a benchmark in this study. Section 3 describes construction of the model, in which a minor region secedes. Section 4 presents comparison of the equilibrium under an integrated economy with that under secession and presents derivation of the condition in which the government of a minor region determines secession from the home country. Finally, we conclude the article and show some possible extensions.

Ⅱ The model

Ⅱ.1 *Integrated economy*

Ⅱ.1.1 *Households*

We consider the country as composed by two regions： region 1 and region 2. Here we assume that region 1 has a larger population than region 2. Therefore, we define region 1 and region 2 respectively as a major region and a minor region. This economy has workers of two kinds. One of them is a worker employed in the service sector. The other is a worker employed in consumption goods sector. Following Krugman [7], the numbers of workers employed in the service and consumption goods sector are denoted respectively by μL and $(1-\mu)L$. Moreover, the number of workers of consumption goods in each region is fixed and given as $(1-\mu)L/2$[2]. Because we assume that region 1 is a major region, the number of households in region 1 is larger than that in region 2. Let L_X^i represent the number of workers employed in the service sector of region $i(=1,2)$. We define θ as the ratio of workers in region 1 to the total number of workers in a country denoted by L, i.e., $L_X^1=\theta\mu L$, $L_X^2=(1-\theta)\mu L$, and $\theta>1/2$. Both regions have a service sector and a consumption goods sector, respectively denoted as X and Y. Similarly to most core-periphery models, the service sector is differentiated among varieties and a monopolistic competition market. Let $s(m)$ represent the consumption of variety m of households. Because we assume that $s(m)$ is a service, it is not transported between regions. Regarding consumption goods, we treat consumption goods as numeraire. Presuming that consumption goods have been transported between regions without transportation cost, their prices are common and given as one.

Finally we consider that natural resources exist in an economy. Although region 1 has more households than region 2, natural resources are unevenly distributed in region 2. The natural resources is owned by the central government, which supervises both regions and which brings a benefit denoted by $\overline{R}$[3]. Moreover, it is redistributed to households there. Because the central government owns it under integrated economy, the benefit from natural resources is redistributed evenly among all households irrespective of the region. All households have a common preference irrespective of region and obtain utility by the consumption of differentiated services and consumption goods. Because each service is differentiated, we assume that service markets are monopolistic competition markets. We specify the utility function of households in a country as

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２　We do not consider movements of workers in the service good sector and consumption goods sector between sectors because consumption goods workers have no skills to work in the service sector. Consequently, the respective sector wages are not necessarily equivalent.

３　For simplification of analysis, we assume that the resources are not consumed in an economy. The central government, which manages resources, sells the resources outside the country. Therefore, we deal with them as an exogenous parameter.

$$U_i = C_X^{\mu} C_Y^{1-\mu}, \ (i = 1,2), \tag{1}$$

where C_X is given as

$$C_X \equiv \left[\int_0^N s(m)^{(\sigma-1)/\sigma} dm \right]^{\sigma/(\sigma-1)}, \ \sigma > 1$$

where $s_{(m)}$ and N respectively denote each service and numbers of variety. Each household has a unit of labor and supplies it inelastically. When we designate w_j^i as the wage of sector $j(= X, Y)$ in region $i(= 1,2)$, the budget constraint is given as

$$w_j^i + I = \int_0^N p(m)s(m)dm + C_Y, \tag{2}$$

where I, N, and $p(m)$ respectively stand for redistribution, the number of variety, and the price of variety m. They determine consumption of the consumption goods and each variety to maximize the utility function subject to (2). Moreover, substituting the demands of each variety and consumption goods for (1), we can obtain the following indirect utility function :

$$V = \mu^{\mu}(1-\mu)^{1-\mu} P^{-\mu}(w_j^i + I), \tag{3}$$

where P is price index of service market in an integrated economy as shown below.

$$P \equiv \left[\int_0^N p(m)^{1-\sigma} dm \right]^{\frac{1}{1-\sigma}} \tag{4}$$

Ⅱ.1.2 *Products*

We refer to production sectors in an integrated economy. First, we explain the consumption goods sector. We describe the production structure of the consumption goods sector. We assume that the consumption goods market is perfectly competitive and assume that one unit of consumption goods is produced with one unit of labor. Moreover, the equilibrium wage in an integrated economy is one because we assume that consumption goods incur no transportation costs between regions. Therefore, $w_Y^i(= 1,2)$ is equal to one.

Regarding the production structure of the service sector, services are mutually differentiated and face monopolistic competition. Following Dixit and Stiglitz [6], we describe the monopolistic competition market. Labor is the only input factor to produce services and consumption goods. A service uses α unit of labor in its region as the marginal input to produce one unit of service. Moreover, each service variety pays a fixed input requirement that comprises β units of labor. Therefore, the labor input of variety m is given as $\alpha s(m) + \beta$. Each service variety maximizes its profit with respect to $p(m)$ under the monopolistic competition market. Each service variety deals with the constant elasticity substitution σ and has no effect on price index of service market denoted by P. Consequently, the price of each service is derived as shown below.

$$p^*(m) = \left(\frac{\alpha\sigma}{\sigma - 1}\right) w_X \tag{5}$$

Because it is assumed that σ is larger than one, the equilibrium price of service under an integrated economy is given as a mark-up of the marginal cost. Assuming the free market entry and exit of variety in service sector, the equilibrium profit of each variety becomes zero. When $s^*(m)$ denotes the equilibrium output of variety in an integrated economy, the following zero profit condition is given as

$$\left(\frac{\alpha\sigma}{\sigma - 1}\right) w_X s^*(m) - w_X(\alpha s^*(m) + \beta) = 0. \tag{6}$$

Presuming that each variety in the service sector is symmetric, the equilibrium price and output are also symmetric. Therefore, we define p^* and s^* as the equilibrium price and output of variety in service sector in an integrated economy, i.e.,

$$p^* \equiv p^*(m), \;\; s^* \equiv s^*(m), \;\; m \in [0, N].$$

Although we treat the number of varieties in the service sector as given, it is necessary to determine it endogenously. The labor demand of each variety in equilibrium is given as $\beta\sigma$. Because the number of workers in a service sector in an integrated economy is given by μL, the labor market clear condition in this sector is the following.

$$\mu L = N \beta\sigma$$

Consequently, we derive the number of variety in a service sector under an integrated economy as follows.

$$N^* = \frac{\mu L}{\beta\sigma} \tag{7}$$

From the assumption of production symmetry, we revise the following equilibrium price index of service sector in an integrated economy.

$$P^* = \left[\int_0^N p^{1-\sigma} dm\right]^{\frac{1}{1-\sigma}} = \left(\frac{\alpha\sigma w_X}{\sigma - 1}\right)\left(\frac{\mu L}{\beta\sigma}\right)^{\frac{1}{1-\sigma}} \tag{8}$$

From comparative statics of (8), we know that the increase in workers of service sector engenders a decrease in the equilibrium price index and an increase in the indirect utility function in equilibrium. Taking account of the equilibrium price of variety, the price index of service sector and the zero profit function, we derive the equilibrium wage of service sector as follows[4].

$$w_X^* = \frac{(1-\mu) + I}{(1-\mu)L} \tag{9}$$

Ⅱ.1.3 *Natural resources*

Although natural resources are located in region 2, they are owned by the central government for both regions. Therefore, the central government derives benefit from these natural resources and redistributes them to households. Considering that the number of households is denoted by L, the redistribution for each household is $I = \overline{R}/L$.

Because the indirect utility function and the equilibrium wage of service sector are given respectively as (3) and (9), we derive the equilibrium utility function of workers and consumption goods workers as

$$V_X^* = \mu^\mu (1-\mu)^{1-\mu} P^{-\mu}\left(w_X^* + \frac{\overline{R}}{L}\right) \tag{10}$$

and

$$V_Y^* = \mu^\mu (1-\mu)^{1-\mu} P^{-\mu}\left(1 + \frac{\overline{R}}{L}\right) \tag{11}$$

From comparative static analyses of indirect utility functions with respect to the total

4 For derivation of this wage, see Appendix A.

number of households in an economy and the benefit from natural resources, we know the effects of them on each indirect utility in equilibrium. However, the increase in population does not necessarily increase utility. In this model, the increase in population gives effects of two kinds. Although the increase in population increases the number of variety of service, it also decreases the income effect because of decreasing redistribution of benefits from natural resources. Therefore, we derive the following proposition.

Proposition 1

In the integrated economy, the increase in population increases (decreases) utility in equilibrium when the effects of a population increase on the number of variety are larger (smaller) than the effects on income redistribution.

Considering (10) and (11), the weighted indirect utility function defined by V^* is given as

$$\begin{aligned} V^* &= \mu V_X^* + (1-\mu)V_Y^* \\ &= \Omega\left[\left(\frac{\alpha\sigma}{\sigma-1}\right)\left(\frac{\mu L}{\beta\sigma}\right)^{\frac{1}{1-\sigma}}\left(\frac{(1-\mu)L+I}{(1-\mu)L}\right)\right]^{-\mu} \times \left\{\mu\left(\frac{(1-\mu)+I}{(1-\mu)L}\right)+1-\mu+I\right\}, \quad (12) \end{aligned}$$

where Ω denotes $\mu^{\mu}(1-\mu)^{1-\mu}$. When the government of the minor region considers secession, it must compare the weighted indirect utility function after secession with (12). From (12), the weighted utility function under an integrated economy depends on L and I, which are the number of population in the economy and the amounts of natural resources. In the next section, we consider the case in which a minor region secedes.

Ⅲ Secession

Ⅲ.1 *Economy after secession*

Ⅲ.1.1 *Households*

In the previous section, we considered the economy as composed by two regions. Because we assume central government owns the ownership of natural resources located in region 2 and redistributes the benefit from it to each household in the integrated economy, there is no difference between the major region (region 1) and minor region (region 2). In this section, we consider the case, in which region 2 secedes from the integrated economy (home country). Because we assume that region 2 has less population than region 1, the populations in region

1 and region 2 are given respectively by θL and $(1-\theta)L$. Presuming that the ratio of workers to total population in each region is common, the numbers of workers in region 1 and region 2 are given respectively by $\mu\theta L$ and $\mu(1-\theta)L$. However, the number of consumption goods workers in region 1 and region 2 are given respectively by $\theta(1-\mu)L$ and $(1-\theta)(1-\mu)L$. Considering the service sector, which is a monopolistic competition market, in an economy, each service variety is spatially immobile ; each region needs a supply of all service varieties by itself after the secession of region 2. Regarding consumption goods, we consider that consumption goods are mobile between regions without transportation cost. Let V_j^i represent the indirect utility function of households $j(=X,Y)$ in region $i(=1,2)$. Presuming that the preference of households does not change after the secession of region 2, we obtain a demand function and an indirect utility function similar to those under an integrated economy. Although a household's preference is not different from that in the previous section, we define the price and demand of variety in service sector, and price index after secession again to distinguish it from the discussion about them clearly in the previous section. Here we define $p_i(m)$, $s_i(m)$, N_i, and P_i respectively as the price and demand of variety m, the number of variety in region i, and price index of service sector in region i after secession. Using those definitions and solving the utility maximization problem, we obtain the following indirect utility function of households employed in sector j in region i.

$$V_j^i = \mu^{\mu}(1-\mu)^{i-\mu}P_i^{-\mu}(w_j^i + I_i),\ \ (i=1,2, j=X,Y) \tag{13}$$

Although the price index of service sector and redistribution of benefit from natural resources do not affect (3) regardless of the regions, we know that (13) is affected by them.

Ⅲ.1.2 *Products*

As for the production sector, we assume an economy consisting of a service sector and a consumption goods sector as well as those in the previous section. Although the consumption goods market is perfectly competitive, the service market faces a monopolistic competition market in this section. Similar to the previous section, we consider that the consumption goods market is perfectly competitive and deal with it as numeraire. Because we assumed that one unit of labor is necessary to produce one unit of consumption goods, the wages in the consumption goods sector are equal to one, i.e., $w_Y^1 = w_Y^2 = 1$. The profit function of variety m in region i is given as

$$\pi_i(m) = p_i(m)s_i(m) - w_X^i(\alpha s_i(m) + \beta). \quad (i = 1, 2) \tag{14}$$

Although varieties are mutually differentiated, the behavior of each variety does not affect the price index in the service sector under a monopolistic competition model. Taking account of this point, we obtain the price of variety in the service sector in equilibrium as follows.

$$p_i(m) = \left(\frac{\alpha\sigma}{\sigma - 1}\right) w_X^i \quad (i = 1, 2) \tag{15}$$

When the monopolistic competition market is followed by Dixit and Stiglitz [6], the equilibrium price of variety is described by a mark-up of the marginal cost. Substituting (15) for the profit function of service sector, we derive the number of varieties in equilibrium from the zero profit function. Let L_x^i represent the number of workers in the service sector in region $i (= 1, 2)$. The equilibrium number of variety in region i is given as

$$N_i = \frac{L_X^i}{\sigma\beta}, \quad (i = 1, 2) \tag{16}$$

where L_X^1 and L_X^2 are given as $\theta\mu L/\sigma\beta$ and $(1-\theta)\mu L/\sigma\beta$[5]. Because the price index of the service sector is aggregated as $P_i = \left[\int_0^{N_i} p_i(m)^{1-\sigma} di\right]^{\frac{1}{1-\sigma}}$, price indexes of the service sector in region i are given as

$$P_1 \equiv \left(\frac{\alpha\sigma}{\sigma - 1}\right)\left(\frac{\theta\mu L}{\sigma\beta}\right)^{\frac{1}{1-\sigma}} w_X^1 \tag{17}$$

and

$$P_2 \equiv \left(\frac{\alpha\sigma}{\sigma - 1}\right)\left(\frac{(1-\theta)\mu L}{\sigma\beta}\right)^{\frac{1}{1-\sigma}} w_X^2 \tag{18}$$

Substituting (15), (16), (17), and (18) for zero profit condition in each region under secession, we derive the following equilibrium wage in region i, which is denoted by w_X^i. That is,

$$w_X^1 = \frac{(1-\mu)\theta L + I_1}{(1-\mu)\theta L} \tag{19}$$

5　Because we assume region 1 and region 2 respectively as a major region and a minor region, the distribution of workers denoted by θ holds that θ is larger than 0.5.

and

$$w_X^2 = \frac{(1-\mu)(1-\theta)L + I_2}{(1-\mu)(1-\theta)L} \tag{20}$$

Ⅲ.2 *Natural resources under secession*

Next we consider the allocation of benefits from natural resources. In the previous section, we assumed that the central government including both regions owns natural resources and redistributes the benefits from natural resources to all households irrespective of region. However, because these natural resources are located in region 2, it is important for each region how these resources are allocated for each region. Now we define ϕ as the allocation ratio of natural resources for region 2. The allocation ratio of natural resources for region 1 is given as $1-\phi$. Therefore, the distribution of benefits from natural resources are, respectively, given as I_1^* and I_2^*.

$$I_1^* = \frac{(1-\phi)\overline{R}}{\theta L}, \quad I_2^* = \frac{\phi\overline{R}}{(1-\theta)L} \tag{21}$$

Ⅲ.3 *Equilibrium under secession*

In the previous section, we obtained equilibrium under secession. Each region considering secession compares the situation under secession with that under non-secession. If the utility of households in a region becomes lower after secession, a region might not choose secession. However, if the region can enjoy a higher utility level after secession, then they might choose secession. To begin with, we derive the equilibrium price index of each region for comparison before and after secession. Substituting (19) and (20) for (17) and (18), respectively, the equilibrium price indexes in region 1 and region 2 are equivalent to those shown as follows.

$$P_1^* = \left(\frac{\alpha\sigma}{\sigma-1}\right)\left(\frac{\theta\mu L}{\sigma\beta}\right)^{\frac{1}{1-\sigma}}\left(1+\frac{(1-\phi)\overline{R}}{(1-\mu)(\theta L)^2}\right) \tag{22}$$

and

$$P_2^* = \left(\frac{\alpha\sigma}{\sigma-1}\right)\left(\frac{(1-\theta)\mu L}{\sigma\beta}\right)^{\frac{1}{1-\sigma}}\left(1+\frac{\phi\overline{R}}{(1-\mu)((1-\theta)L)^2}\right) \tag{23}$$

Because the sum of the wage income and redistribution in region 1 is derived as $w_X^1 + I_1^*$, the sum of wage income and redistribution in region 1 under an equilibrium is

$$w_X^{1*} + I_1^* = 1 + \frac{(1+(1-\mu)\theta L)(1-\phi)\overline{R}}{(1-\mu)(\theta L)^2}.$$

Similarly to the derivation of $w_X^{1*} + I_1^*$, $w_X^2 * + I_2^*$ can also be obtained as

$$w_X^{2*} + I_2^* = 1 + \frac{(1+(1-\mu)(1-\theta)L)\phi\overline{R}}{(1-\mu)((1-\theta)L)^2}.$$

Substituting (18), (19), and (20) for (12), the indirect utility function of workers or consumption goods workers of sector i in region j are given as presented below.

$$V_X^{1*} = \mu^\mu (1-\mu)^{1-\mu} (P_1^*)^{-\mu} \left\{ 1 + \frac{[1+(1-\mu)\theta L](1-\phi)\overline{R}}{(1-\mu)(\theta L)^2} \right\}, \tag{24}$$

$$V_Y^{1*} = \mu^\mu (1-\mu)^{1-\mu} (P_1^*)^{-\mu} \left(1 + \frac{(1-\phi)\overline{R}}{\theta L} \right), \tag{25}$$

$$V_X^{2*} = \mu^\mu (1-\mu)^{1-\mu} (P_2^*)^{-\mu} \left\{ 1 + \frac{[1+(1-\mu)(1-\theta)L]\phi\overline{R}}{(1-\mu)((1-\theta)L)^2} \right\}, \tag{26}$$

and

$$V_Y^{2*} = \mu^\mu (1-\mu)^{1-\mu} (P_2^*)^{-\mu} \left(1 + \frac{\phi\overline{R}}{(1-\theta)L} \right) \tag{27}$$

From (24)-(27), we know that the equilibrium indirect utility function under secession is described by some parameters : α, β, σ, μ, θ, ϕ, L, and $\overline{R}$. We assume that each government takes account of the weighted indirect utility function of both workers and compares it with the indirect utility function before secession when their own region secedes or not. Here we define $\hat{V}_i$ as the weighted indirect utility function of both workers in region $i(=1,2)$ after secession. Because we assume that the weight ratio is equal to the ratio of both workers $\hat{V}_i$ is given as

$$\hat{V}_i^* = \mu V_X^{i*} + (1-\mu) V_Y^{i*}, \ \ (i = 1,2) \tag{28}$$

Substituting (24), (25), (26), and (27) for (28), $\hat{V}_1$ and $\hat{V}_2$ are given as follows.

$$\hat{V}_1^* = \Omega (P_1^*)^{-\mu} \left[1 + \frac{[\mu + (1-\mu)L\theta](1-\phi)\overline{R}}{(1-\mu)\theta^2 L^2} \right] \tag{29}$$

$$\hat{V}_2^* = \Omega(P_2^*)^{-\mu}\left[1 + \frac{\left[\mu + (1-\mu)(1-\theta)L\right]\phi\overline{R}}{(1-\mu)((1-\theta)L)^2}\right] \tag{30}$$

Ⅳ Remain or secede

Ⅳ.1 *Allocation rate of natural resources and population distribution*

We consider whether the minor region (region 2) decides to secede or not in this section. As we have already explained for secession, the government in region 2 compares the weighted utility after secession with that before secession to choose to secede from the integrated economy. The government in region 2 compares (30) with (12). We assume that θ is larger than 0.5. Because the indirect utility functions, which are (29) and (30), include price index of service sector, which are (22) and (23), we consider the effects of the population distribution between regions and the allocation ratio of natural resources for region 2 on price index of service sector in region 1 and region 2. Differentiating (22) and (23) with respect to θ, we know that the increase in θ decreases (increases) price index of service sector in region 1 (region 2).[6]

$$\frac{\partial P_1^*}{\partial \theta} < 0, \ \frac{\partial P_2^*}{\partial \theta} > 0$$

Next, we analyze the effect of allocation ratio of natural resources for region 2 on the price index in each region. Differentiating (22) and (23) with respect to ϕ, we derive the following results.

$$\frac{\partial P_1^*}{\partial \phi} < 0, \ \frac{\partial P_2^*}{\partial \phi} > 0$$

Therefore, we know that the increase in ϕ decreases (increases) price index of service sector in region 1 (region 2).

$$\frac{\partial \hat{V}_1^*}{\partial \phi} = \Omega\Bigg\{ -\mu(P_1^*)^{-\mu-1}\frac{\partial P_1^*}{\partial \phi}\left[1 + \frac{(\mu + (1-\mu)L\theta)(1-\phi)\overline{R}}{(1-\mu)\theta^2 L^2}\right] - (P_1^*)^{-\mu}\left[\frac{(\mu + (1-\mu)L\theta)\overline{R}}{(1-\mu)\theta^2 L^2}\Bigg\}\right] \gtreqless 0 \tag{31}$$

From (31), we know that the increase in ϕ is not necessary decrease the weighted indirect

6　As for the effect of θ on price index in each region, please see Appendix B.

utility in region 1 after secession. Similarly to comparative statics of (31), the effect of ϕ on weighted indirect utility in region 2 after secession is also given as

$$\frac{\partial \hat{V}_2^*}{\partial \phi} = \Omega\left\{ -\mu(P_2^*)^{-\mu-1}\frac{\partial P_2^*}{\partial \phi}\left[1+\frac{\left[\mu+(1-\mu)(1-\theta)L\right]\phi\overline{R}}{(1-\theta)L}\right] + (P_2^*)^{-\mu}\frac{\left[\mu+(1-\mu)(1-\theta)L\right]\overline{R}}{(1-\theta)L}\right\} \gtreqless 0 \tag{32}$$

The sign of $\frac{\partial \hat{V}_2^*}{\partial \phi}$ is not determined uniquely. This result is extremely interesting because, intuitively, an increase in the allocation ratio to natural resources should be desirable for region 2. In our model, however, we derived results that were counterintuitive by (32). We assign this result the following economic interpretation[7].

Ⅳ.2 *Numerical example*

Finally we analyze the secession condition of the minor region (region 2) from the home country. The government in region 2 compares the weighted indirect utility after secession with that before secession. Presumably, if the former indirect utility is greater than the later, then the government in region 2 will secede from the home country. However, if the former is less than the latter, the government in region 2 will give up secession from the home country. Because the weighted indirect utility functions before and after secession are given as (12) and (30), the government in region 2 has an incentive to choose secession from the home country when the following relation holds.

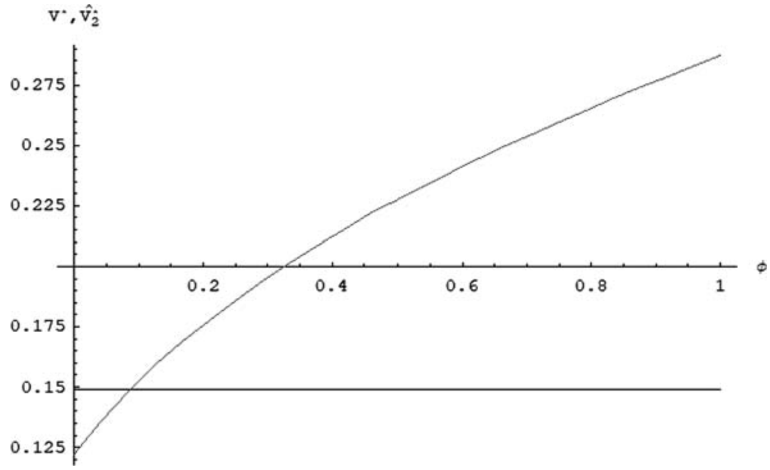
$$\hat{V}_2^* \geq V^* \tag{33}$$

Figure 1 depicts the level of weighted indirect utility in region 2 before and after secession. The bold line and solid line respectively denote the weighted indirect utility in region 2 before and after secession[8]. When the solid line is located above the bold line, the weighted indirect utility after secession is greater than that before secession. From Figure 1, one can infer that (33) holds when ϕ is large. Region 2, with a small population, does not hope for secession unless sufficient interests related to natural resources are guaranteed after secession. Because

7　It is noteworthy that ϕ that maximizes utility exists between zero and one is not always guaranteed because we assume that the range of ϕ is from zero to 1. Therefore, we do not rule out the possibility that ϕ will be a corner solution.

8　Figure 1 shows the following parameters : $\sigma=4$, $\mu=0.6$, $\alpha=3$, $\beta=2$, $\overline{R}=3$, $L=10$, $\phi=0.5$, and $\theta=0.9$.

Fig. 1 Indirect utility before and after secession.



the population distribution between region 1 and region 2 in Figure 1 is given as $\theta = 0.8$, this numerical example shows the secession condition of region 2 (minor region) when the difference of regional scale is large. Moreover, we can present the following economic interpretation. Because the number of service varieties in region 2 decreases after secession, the price index of the service goods sector there increases. The utility of households there decreases. Obtaining sufficient interest from natural resources is necessary for the household average indirect utility after secession to become greater than that before secession. Region 2 will try to secede from the home country if the interests on natural resources after secession are sufficiently large. However, the government of the home country including major region (region 1) can deter the secession of minor region (region 2) from the home country.

Proposition 2 :

When interest rights of natural resources of a minor region (region 2) are not so strong, the government in the minor region has no incentive to secede from the home country.

Ⅴ Concluding remarks

We constructed a model in which natural resources are unevenly distributed. We used it to analyze the effects of interest rates applied to natural resources on regional secession. We extend the core-periphery model by introducing unevenly distributed resources. Our model has effects of two kinds. One of them is an income effect with the origin of natural resources. Because natural resources are unevenly distributed in the minor region (region 2), their interest rate of it brings incentives to secede to the minor region. The other is the decreasing effect of economy of agglomeration caused by the decrease in population. Consequently, whether local governments secede or not depends on the trade off between these two effects. Because we assume that the total population of both regions is constant and because they are immobile between regions after secession, the decrease in population engenders a decrease the number of variety there and decreases the utility level. Moreover, presuming that the minor region can maintain the interest rate of natural resources, the minor region maintains it after secession. If it is sufficiently large, the government of the minor region has an incentive to secede from the home country. In other words, the home country containing the major region can reduce the incentive to secede of the minor region by adequately ensuring the interests of the unevenly distributed natural resources. Most previous studies of secession introduce public goods into the model because the shortcomings of secession arise from them. Although our model does not address public goods, we derived a result similar to that reported by Ohno [8].

However, our model includes some points to be revised in future studies. One is the assumption that households are immobile between regions after secession. In the real economy, population migration between regions is frequently apparent even after secession. The other is that we consider only service goods sector and consumption goods. The model is expected to become more difficult if we consider not only a service goods sector but a manufactured goods sector because we must consider transportation costs when we consider manufactured goods in the model. This point stands as an important point for future analysis.

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A Derivation of wage rate in service sector

Maximizing (1) subject to (2), the demand for variety m of workers and consumption goods workers is given as

$$s(m) = \frac{\mu w_X}{p(m)^{\sigma} P^{1-\sigma}},\ s(m) = \frac{\mu}{p(m)^{\sigma} P^{1-\sigma}}$$

Consequently, taking account of the Cobb-Douglas utility function, the following aggregated demand of variety m is

$$s(m) = \frac{\mu M}{p(m)^{\sigma} P^{1-\sigma}},\ \ M \equiv \mu L w_X + (1-\mu) + I, \tag{A. 1}$$

where M denotes aggregated income of households in an economy. The profit function of variety m is given as

$$\pi(m) = (p(m) - \alpha w_X) \times \frac{\mu M}{p(m)^{\sigma} P^{1-\sigma}} - \beta w_X. \tag{A. 2}$$

Moreover, substituting (5) for (9), we revise the price index of the service sector as follows.

$$P = N^{\frac{1}{1-\sigma}} \left(\frac{\sigma\alpha}{\sigma-1}\right) w_X \tag{A. 3}$$

Substituting (5) and (A.3) for (A.2) and taking account of the zero-profit condition, we derive the wage of service sector in equilibrium as follows.

$$w_X^* = \frac{(1-\mu) + I}{(1-\mu)L} \tag{A. 4}$$

B　Effect of θ on price index of service sector in each region

First, we consider the effects of θ on the price index of the service sector in region 1. Because the price index of the service sector in region 1 after secession is given as (22), we differentiate (22) with respect to θ. Consequently, the effect of θ on it is given as

$$\frac{\partial P_1^*}{\partial\theta}=\left(\frac{\alpha\sigma}{\sigma-1}\right)\left(\frac{\mu L}{\sigma\beta}\right)^{\frac{1}{1-\sigma}}\left\{\frac{1}{1-\sigma}\theta^{\frac{1}{1-\sigma}-1}\left(1+\frac{(1-\phi)\overline{R}}{(1-\mu)(\theta L)^2}\right)-2\theta^{\frac{1}{1-\sigma}+1}\left(\frac{(1-\phi)\overline{R}}{(1-\mu)L^2}\right)\right\}<0 \tag{B. 1}$$

Given that (B.1) is a decreasing function with respect to θ, then the higher the ratio of population in region 1 to the total population becomes, the lower the price index of the region 1 service sector will be. Similarly to (B.1), we also confirm the effect of θ on price index of it in region 2.

$$\frac{\partial P_2^*}{\partial\theta}=\Gamma\left\{-\frac{1}{1-\sigma}(1-\theta)^{\frac{1}{1-\sigma}-1}\left(1+\frac{\phi\overline{R}(1-\theta)^2}{(1-\mu)(L)^2}\right)+(1-\theta)^{\frac{1}{1-\sigma}}\left(\frac{2(1-\theta)\phi\overline{R}}{(1-\mu)(L)^2}\right)\right\}>0 \tag{B. 2}$$

Conversely, the increase in θ increases the price index of the service sector in region 2.