Analysis of self-sustaining rural economic system as a wider-areal regional management[1]

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Abstract The management of self-sustaining economic system can be a part of primary concerns to argue practical spatial policies in actual regions. An effective remedy may be an improvement of physical access to the market as well as achieving a better resource allocation within the spatially constrained economic plane. However, there is a difficulty to keep a normal profit for the local economic agent, in particular, areas which insufficient economies are present. This paper demonstrates a cooperative coordination among different neighbouring areas. An extensive framework applies a fundamental treatment of the hierarchical central place system together with the notion of regional externalities. The analysis of self-sustaining rural economic system in our paper employs a wider-areal regional management which may be applicable to existing current problematic areas.

JEL Classification: C71, D62, I31, O18, R58
Keywords: regional management, transportation policy, hierarchical central place system, agglomeration economies, economics of location

1 Introduction

Countries such as Japan, Korea, Chile, and Thailand rely on the regional economic growth in the capital city or capital region such as Tokyo, Seoul, Santiago, and Bangkok. From the standpoint of resource allocation, it would be better to utilise other areas including rural regions unless there is no urbanisation diseconomy caused by a severe spatial concentration of the economic activity at the central place. One of struggles to sustain

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[1] *This is a draft and please do not quote.*

regional economic growth in rural areas is the presence of insufficient economies of scope in addition to insufficient economies of scale. The insufficient economies of scope do not enhance the attractiveness of a region, as Nakamura (2018) demonstrated that the attractiveness of a region is brought about by the achievement of “a love of variety” (see Dixit and Stiglitz (1977), and Ethier (1982)), which may be applicable both to the firm and to the individual.

Under such a background, we present a wider-areal regional management can partly solve the problem with the economies of scope and of scale. Also, here the argument aims to indicate spatial policies for a self-sustaining rural economic system in a specific condition. The parameter includes transportation costs, decision-making of economic agents for their optimal location and for the social optimum of the location of economic activity under a physically limited economic space. In order to argue about the social optimal, it is necessary to employ the notion of cooperative coordination which has already been addressed by Isard (1975). Further, the optimal location problem with the notion of transportation costs, market-area analysis as central place theory with hierarchical spatial system by Lösch (1944 [1954]) plays an important role. In addition, centripetal force to specific areas should refer to agglomeration economies (i.e., Weber (1909 [1928]), Hoover (1937), Isard (1956), Evans (1972), and Parr (2002)). As an advanced framework, Parr (2015) named “regional externalities” which can be directly connected to the argument of this paper.

When regional externalities less work due to limited economies of scale within a region, an extensive framework would be a wider-areal coordination among neighbouring different areas. In such an approach, physical accessibility (i.e., distance) and transportation costs are important to include in the analysis. A fundamental framework can be referred to Launhardt (1885) and more advanced expansions were made by Vickerman (1991), for instance. Regarding transportation costs, location theory has a trade-off to agglomeration economies. A basic concept was indicated by Weber (1909 [1928]) and detailed by Isard (1956) for industrial location decision-making. Apart from industrial terms, specific attractive forces for migrants or households were examined by Glaeser et al. (2001) and Rodriguez-Pose and Ketterer (2012) as well as regional welfare analysis by Isard (1975).

In Section 2, a simple regional economic model is introduced, which will be followed by analysis on regional system in Section 3. Spatial policy is then presented in Section 4, and further avenues are explored in Section 5 before concluding comments in Section 6.

2 Regional Economic Model

In this section, a simplified regional economic model is presented. Here, the following situation is assumed. First, a representative firm engages on a production. The produced product, $y\ (y > 0)$, is supplied to its region or export to other regions. Second, the product, y, is assembled by using two types of input, $x_1\ (x_1 > 0)$ and $x_2\ (x_2 > 0)$. Each input has a price $w_1\ (w_1 > 0)$ for x_1, and $w_2\ (w_2 > 0)$ for x_2, respectively. The firm maximises his profit under a given production function as described in (2).

$$\max \quad \pi = py - w_1x_1 - w_2x_2 \tag{1}$$

$$\text{s.t.} \quad y = f(x_1, x_2) \tag{2}$$

By testing the first-order necessary condition and the second-order sufficient condition, the optimal quantity of output is determined. This argument can also apply to regional economic services such as public transportation. Here, an attention is given to the regional economic management using this fundamental idea. To be concrete, a problem occurs when the economic system faces insufficient economies of scale that would be more evident in rural areas. Also, the economies of scope may have important roles to keep an attractiveness of a region, particularly at non-central places or lower hierarchically-ordered areas.

For industrial location decision-making of firms, Isard (1956) applied a framework of Weber (1909 [1928]). Figure 1 illustrates initial locations of production site of three different firms, PL_1, PL_2, and PL_3, respectively. Each circle represents a critical isodapane. In this case, two firms would choose a common point of production plant, if they are all involved in the same industry and they can take advantage of location proximity to other related firms. However, three firms never co-locate because there is no space which all critical isodapanes overlap with each other.

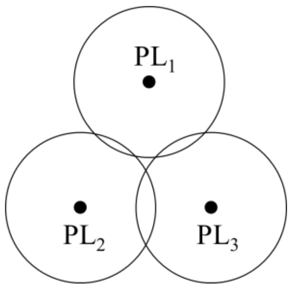

Fig. 1 Weber's location problem

Isard (1956) addressed that a subsidiary payment from firms 1 and 2 to the firm 3 may allow to expand firm 3's critical isodapane so that three firms are able to co-locate at PL^* as shown in Fig. 2. The collocation achieves the economies of agglomeration; namely, localisation economies.

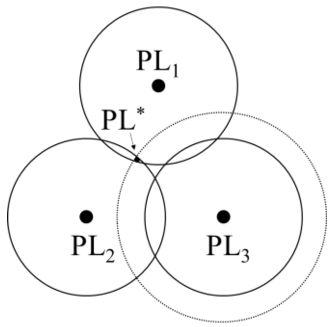

Fig. 2 Subsidiary payment solution (Isard, 1956)

3 Regional System

While industrial location can relocate firm's production site, regional centres may be difficult to do so. Figure 3 presents three neighbouring areas, and they separately engage economic activity with each other. When each area owns sufficient local population and economic activity, they can operate independently with enhancing regional import and export. In the figure, symbols r_i $(i = 1,2,3)$ represents a net regional export in each area R_i. Here, it is assumed that the hierarchical order of regional scale is $R_1 > R_2 > R_3$. Among different neighbouring areas, it is also possible to exchange goods and services by using the local transportation network. Namely, the distance d_{12} and d_{21} between R_1 and R_2, d_{23} and d_{32} between R_2 and R_3, and d_{13} and d_{31} between R_1 and R_3. If unit transportation cost is set as a constant t $(t > 0)$, transportation costs from R_1 to R_2 is td_{12}. Similarly, its opposite direction will be td_{21}. In this way, three areas' total transportation costs become $t\big(2d_{12}(q_1 + q_2) + 2d_{23}(q_2 + q_3) + 2d_{31}(q_3 + q_1)\big)$ where $d_{ij} = d_{ji}$ $(i \neq j)$ and q_i $(q_i > 0, i = 1,2,3)$ = quantity demanded of commodities at i. If such network is more beneficial than the regional export and import r_i, all three areas should establish a neighbouring areal economic partnership as an integrated framework.

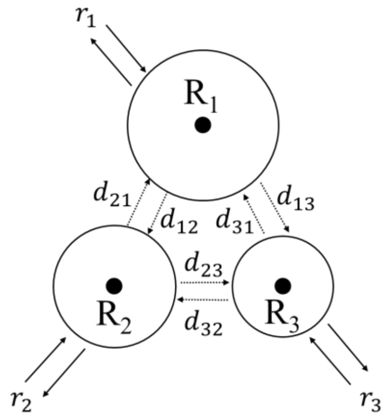

Fig. 3 Rural sustainable economic problem

A problem can be observed when there are insufficient economies of scale due to a constant decline of local population and economic activity. When the spatial arrangement is for a regional development, it is not plausible to relocate the centre at a common site as already been argued. Hence, a consideration should be given to a development on physical and network connectivity to other neighbouring areas as demonstrated in Fig. 3

It is a common problem that rural infrastructure development does not properly work in particular at rural areas. This can be illustrated by the framework of game theory. Table 1 sets two neighbouring areas. Pay-offs are assumed to be $a_{21} > a_{11} > a_{22} > a_{12}$ and $b_{12} > b_{11} > b_{22} > b_{21}$ as commonly discussed on "prisoner's dilemma". In that case, the negotiation for the cooperative behaviour to set up a areal development will be failed under a non-cooperative simultaneous game.

Table 1. Negotiation for a wider-areal cooperative coordination

Area *A*　Area *B*	Cooperative	Not cooperative
Cooperative	a_{11}, b_{11}	a_{12}, b_{12}
Not cooperative	a_{21}, b_{21}	a_{22}, b_{22}

In addition to the conceptual framework of prisoner's dilemma, the failure of the negotiation can be also caused by cost burden for the development.

4 Spatial policies

Hitherto, it has revealed that the wider-areal cooperative coordination may be difficult to establish without effective policies. This section explores how such a potentially problematic issue can be solved. Here, an alternative transportation network may be suggested as depicted in Fig. 4.

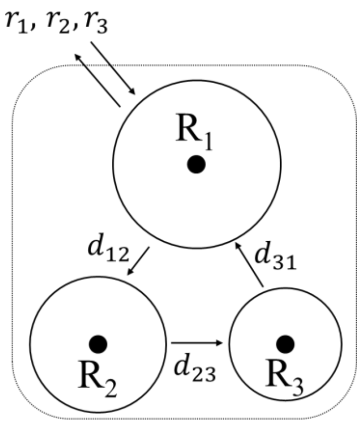

Fig. 4 Wider-areal cooperative coordination

The figure draws one-way network of transportation adjusted by hierarchically-ordered regional system. As assumed in Lösch (1944 [1954]), higher hierarchical-ordered regions own more variety of goods and services. Hence, the direction of the physical transportation route should be from area R_1 to area R_2 to area R_3 in this particular case. Also, regional trade can be integrated to the area R_1 such as a location of seaport and its relevant facilities unless there are severe limitations to use the space at that area.

This specific scenario calculates transportation costs as

$$t((1+\sigma_3-\sigma_1)d_{12}+(1+\sigma_3-\sigma_1-\sigma_2)d_{23}+\sigma_3 d_{31}) \quad (3)$$

where σ_i $(0<\sigma_i<1,\ i=1,2,3)$ represents a relative weight to have commodities to transport in each area R_i. Now, it is necessary to reveal which regional system is better for each area. One is to keep the independent regional economic organisation, and another is to establish an integrated wider-areal regional system. For instance, the latter pattern may be preferred as long as the following condition is satisfied.

$$\sum_{j=1}^{3}\left(tr_j c_j+F_j\right) t[d_{12}(q_1+q_2)+d_{23}(q_2+q_3)+d_{31}(q_3+q_1)] >$$
$$\sum_{j=1}^{3}\left(tr_j c_j+\lambda^{-1}F_j\right)+t[(1+\sigma_3-\sigma_1)d_{12}+(1+\sigma_3-\sigma_1-\sigma_2)d_{23}+\sigma_3 d_{31}] \quad (4)$$

where r_j $\left(r_j>0,\ j=1,2,3\right)$ = the amount of net regional export, c_j $\left(c_j>0\right)$ = unit cost to engage a regional trade, F_j $\left(F_j>0\right)$ = fixed cost to engage the regional trade such as the terminal cost, and λ $(0<\lambda<1)$ = a parameter to achieve cost saving by sharing facilities for the regional trade (i.e., $\lambda \to 1$ as the scale merit is applicable). (see Nakamura, 2019).

If the cost-saving amount sufficiently exceeds the benefit of non-cooperative payoffs, a cooperative behaviour may be taken among two areas. As Table 1 is two-area case, the overall weight for three areas should be assessed by $2/3$ to observe three-area case.

$$\sum_{j=1}^{3}\left(tr_j c_j+F_j\right) t[d_{12}(q_1+q_2)+d_{23}(q_2+q_3)+d_{31}(q_3+q_1)]-\sum_{j=1}^{3}\left(tr_j c_j+\right.$$
$$\left.\lambda^{-1}F_j\right)+t[(1+\sigma_3-\sigma_1)d_{12}+(1+\sigma_3-\sigma_1-\sigma_2)d_{23}+\sigma_3 d_{31}]\cdot\frac{2}{3}>a_{21}-a_{11} \quad (5)$$

$$\sum_{j=1}^{3}\left(tr_j c_j + F_j\right) t[d_{12}(q_1+q_2) + d_{23}(q_2+q_3) + d_{31}(q_3+q_1)] - \sum_{j=1}^{3}\left(tr_j c_j + \lambda^{-1}F_j\right) + t[(1+\sigma_3-\sigma_1)d_{12} + (1+\sigma_3-\sigma_1-\sigma_2)d_{23} + \sigma_3 d_{31}] \cdot \frac{2}{3} > b_{12} - b_{11} \quad (6)$$

Hence, these are strategies to switch from a non-cooperative to a cooperative behaviour. A generalised form, which the condition all pay-offs are assumed to be the same pattern, can be expressed as follows.

$$\sum_{j=1}^{3}\left(tr_j c_j + F_j\right) t[d_{12}(q_1+q_2) + d_{23}(q_2+q_3) + d_{31}(q_1+q_3)] - \sum_{j=1}^{3}\left(tr_j c_j + \lambda^{-1}F_j\right) + t[(1+\sigma_3-\sigma_1)d_{12} + (1+\sigma_3-\sigma_1-\sigma_2)d_{23} + \sigma_3 d_{31}] \cdot \frac{2}{n} > a_{21} - a_{11} \quad (7)$$

$$\sum_{j=1}^{3}\left(tr_j c_j + F_j\right) t[d_{12}(q_1+q_2) + d_{23}(q_2+q_3) + d_{31}(q_1+q_3)] - \sum_{j=1}^{3}\left(tr_j c_j + \lambda^{-1}F_j\right) + t[(1+\sigma_3-\sigma_1)d_{12} + (1+\sigma_3-\sigma_1-\sigma_2)d_{23} + \sigma_3 d_{31}] \cdot \frac{2}{n} > b_{12} - b_{11} \quad (8)$$

where n = the number of areas.

5 Further avenues

While this analysis bases on the methodological framework, it is also important to do calculus using the actual data set. For instance, the DEA (Data Envelope Analysis) by Suzuki and Nijkamp (2018) investigated the regional sustainability of representative large metropolitan cities across Japan. If such a formal treatment is applied to rural regions, it would be possible to indicate rural sustainability of the country which face a constant population declining and less rapid economic growth. This may contribute to indicate what types of regional development are effective.

Another expansion can be an examination of measuring a regional strength. The regional strength directly depends on the extent of regional export (see i.e., Tibout (1956)), which is the same as the benefit brought about by international trade in an open economy.

If an observing region does not have specific products to export to other regions, a remaining possibility may be increasing human capital. In that case, the region needs to satisfy the economies of scope on goods and services, which can be characterised as a love of variety. If the region may not be feasible to satisfy them, it is again important to coordinate a wider-areal spatial structure. Under a situation where the prisoner's dilemma cannot be avoided, an alternative solution is to arrange an opportunity to take a path $(1-\propto)$ in Fig. 5. To do so, the payoffs must at least satisfy $h_{11}b_{11} > a_{12}b_{12}$ and $h_{21}b_{21} > a_{22}b_{22}$, while further discussion is beyond the scope of this paper.

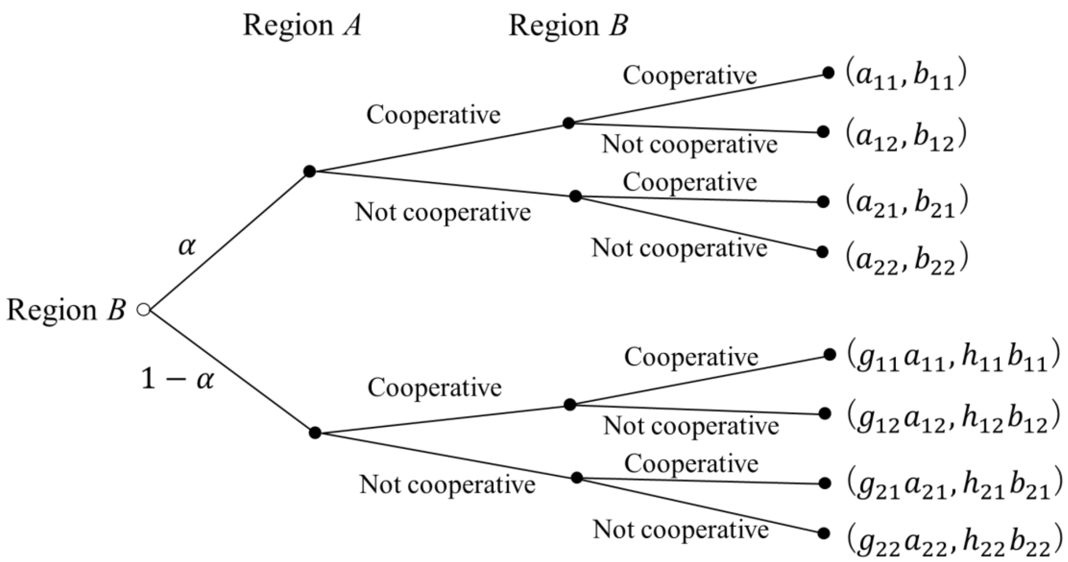

Fig. 5 Game tree

6 Concluding comments

This paper has presented the management of a self-sustaining economic system to show practical spatial policies in actual regions. Here, an improvement of a physical access to the market as well as achieving an efficient cooperative transportation network system is examined. This may cover insufficient economies of scale and of scope in rural areas, and a description applying the fundamental framework of the Löschian hierarchical central place system is provided. There, the notion of regional externalities is expanded to a discussion of wider-areal regional management that satisfies a sustainable regional economic growth in rural areas for the long run.

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