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The role of the urban system in a regional government's location policy

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Abstract

Regional governments carry out a series of plans to attract firms to the area to stimulate the economic activity. The firms which are enticed to locate at the area are selected according to the characteristics of the regional economy. These firms are expected to operate the production processes in harmony with the region's characteristics and develop sustainably the region's economy. While the firms that plan to build a new factory select a region in a large geographical area for the new establishment to maximize profits. They compare the regions' characteristics in terms of their own interests and determine the region for the factory. It is important for both regional governments and firms to understand the social and economic characteristics of regions and their comparative advantages. Present paper, first, examines the process of the location decision-making of a firm in these days in which economic globalization is common. It is theoretically elucidated in this examination why the characteristics of regional economy play an important role in a firm's decision-making on the location of a factory. And then, using the empirical analysis of the relationships between Japanese regional economies and urban systems laid in the regions, the paper shows that the structure of urban system influences the region's social and economic performances. It is concluded from the analysis that the urban systems laid on the regions should be paid more attention by both regional governments and firms because the urban system is related with social and economic achievements in a region and it influences the profit level of the firms and the region's power to attract firms to the area.

Keywords: Urban system, Firm's location, Social health, Chaotic phenomenon,
Second best location, Prospective area.

1. Introduction

Regional governments conduct many plans to attract firms to the area in order to vitalize the economy. The firms which are induced to move to the area are selected considering the characteristics of the regional economy. These firms are expected to operate their production processes in harmony with the region's characteristics and to develop sustainably the economy. While the firms planning a new factory select one among regions for the establishment to maximize profits. They compare the regions' characteristics in terms of their interests, and they determine the region in which the new factory locates. It is, therefore, very important for both regional governments and firms understanding the social and economic characteristics of each region and its comparative advantage over other regions.

The importance of a role of regional economy's characteristics in a firm's location strategy is clearly shown by examining the firm's location decision-making in the recent economic situation in which globalization is common: As the economic barriers separating a local market from other markets are taken down, many firms are exposed to a mega-competition among competitors in the world market. Under the mega-competition the price of goods plays a crucial role, the firms become to lay much more stress on the strategy to reduce the production costs. The firms' primary strategy is to subdivide the production process into small blocs: Because this subdivision simplifies the operation in each production bloc, it becomes very easy for the firms to enjoy economies of scale in the production by introducing machineries and to use a number of unskilled labors with low wage rates in the production. It is common for the firms, therefore, to fragment the production processes and move their factories to suitable places to their production characteristics. Since fragmented processes become small and simple, they are easily moved in the long distance. Thus, firms often face an important location problem that they have to search the best location or the second best location sites for their new factory in an unfamiliar area of a foreign country.

In this case, firms take several processes to determine the location place since they do not have enough information about the economic conditions of all potential location sites. The firms determine the factory's location step by step: In the first step of the determination processes, a certain part of a large geographical space should be settled as *the prospective area* in which the firm's profits obtained at any location sites would not be greatly changed and any location of the factory would be roughly allowed in the terms of firm's profit level. Hence, only in this area the firms collect information necessary to determining the final location place. Then, in the second step the firms determine *a certain region in the prospective area*. Because some regions are covered by *the prospective area* and the social and economic characteristics and the performances are different between the regions. Their differences surely influence the firms' location decision making. The firm selects one region between regions according to the firm's interests. After the selection of the region, the firms get down to determine *the urban area* in the selected *region* for a new factory.

On the other hand, the regional governments make many efforts to attract firms to their area as many as possible in order to vitalize the economic activity. In these days, these efforts of the regional governments seems to operate effectively in attracting the factories to the area since the fragmented production processes are easily departed from the existing industrial area and moved in the long distance. In this situation the urban system is considered to be an important factor for the regional governments to induce the firms to the area because the urban system laid in the region influences the social and economic performances of the region, and, as shown in the above, the level of social and economic performances of a region is an important criterion for the firms to determine the region for a new factory. It leads to the conclusion that making the structure of urban system suitable to the region is an important task for regional governments to attract many firms to their regions. In order to examine this picture this paper examines the relationships between the structures of the urban systems and the elements consisting of performances of the region. The examination suggests that the urban system should be paid more attention of both the regional governments and the firms.

This paper is organized as follows. Section 2 firstly explains the assumptions and the framework of the analysis conducted in this paper, and then it derives the firm's profit function. Using this function, the optimal location site is identified and a chaotic phenomenon appeared in the derivation processes of the optimal location site is also shown. Secondly, it elucidates why chaotic phenomenon is useful for firms to settle *the prospective area* for the factory's location in a large geographical area. Section 3 inquires the relationships between the urban systems and the social and economic performances of regions and it shows that the urban system laid in a region influences the social and economic performances achieved in the region. It is clarified that the structure of urban system is an important location factor when the firms select *the region* of the factory's location in the prospective area. This section explains that the structure of urban system is one of the essential factors for the regional governments to attract the firms to their areas. Section 4 summarizes discussion.

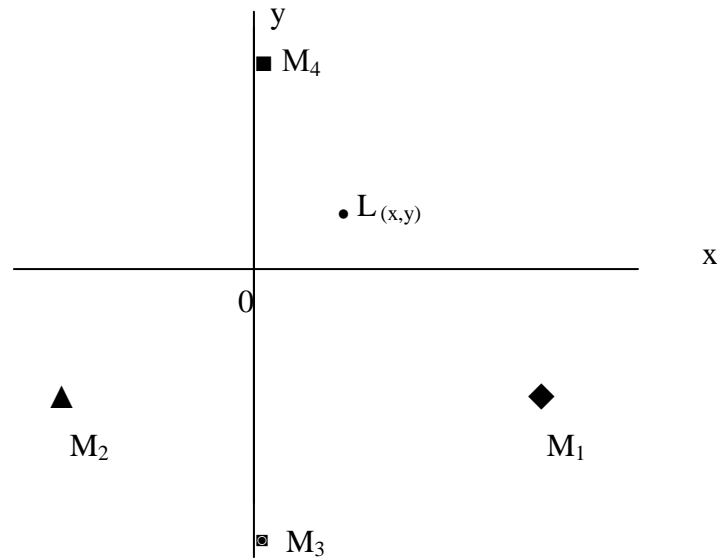
2. The role of chaotic phenomenon in a firm's decision of location

2.1. Assumptions and framework of analysis

This section examines how the firm determines the factory's location in a large geographical space. Let us derive the firm's profit function. A firm's profit function is derived on the following assumptions. A factory uses two kinds of raw materials m_1 , m_2 to produce final goods m_4 . The factory uses an additional material m_3 to complete the goods, that is, fuel or lubrication oil are needed to the operating the production processes. The materials m_1 , m_2 and m_3 are produced at points M_1 , M_2 and M_3 which are identified by coordinates (x_1, y_1) , (x_2, y_2) , (x_3, y_3) , respectively on a large plain space. They are transported to the factory at point L indicated by (x, y) . Freight rates of the materials m_1 , m_2 are denoted by t_m , and the rate of the material m_3 is given by t_e . Mill prices of these materials are shown by p_1 , p_2 , and p_3 , and these prices are given. The price of the finished good

p_4 is determined by the firm to maximize the profits. The finished goods are transported from the factory to the market at point $M_4 (x_4, y_4)$. The freight rate of the finished goods m_4 is t_g . Figure 1 illustrates the geographical relationship between the factory, the market and the producing points of the materials.

Figure 1 Factory's location in large geographical area



The factory's production function is represented by equation (1):

$$Q_S = A m_1^\alpha m_2^\beta \quad (1)$$

where Q_S is quantity produced. A , α and β are parameters and they are defined as $A > 0$, $0 < (\alpha + \beta) < 1$. Market demand function for the finished goods is given by equation (2):

$$Q_d = a - p_4, \quad (2)$$

where Q_d is quantity demanded, a is the maximum reservation price of the finished good. The factory produces just as much goods as the market demands: Q_S must be equal to Q_d . The distances between the producing place M_i ($i=1, 2, 3$) and the factory L are represented by d_1 , d_2 , d_3 , respectively:

$$d_1 = ((x - x_1)^2 + (y - y_1)^2)^{0.5}, \quad (3a)$$

$$d_2 = ((x - x_2)^2 + (y - y_2)^2)^{0.5}, \quad (3b)$$

$$d_3 = (x_2 + (y - y_3)^2)^{0.5}. \quad (3c)$$

The distance between the factory L and the market M_4 is given by d_4 :

$$d_4 = (x_2 + (y - y_4)^2)^{0.5}. \quad (3d)$$

If the amount of the material m_3 is equal to Q_s and the fixed cost is F , the firm's profits Y_M is given by equation (4),

$$Y_M = (a - p_4) ((p_4 - t_g d_4) - (p_3 + t_e d_3)) - (p_1 + t_m d_1) m_1 - (p_2 + t_m d_2) m_2 - F. \quad (4)$$

Making use of the law of equi-marginal productivity, that is, the ratio between the productivities of the two materials should be equal to the ratio between the delivered prices of them, quantities of the materials are derived as equations (5a) and (5b): (For simplicity, α and β are assumed $\alpha = \beta = 0.4$):

$$m_1 = A^{-1.25} (a - p_4)^{1.25} ((p_2 + t_m d_2) / (p_1 + t_m d_1))^{0.5}, \quad (5a)$$

$$m_2 = A^{-1.25} (a - p_4)^{1.25} ((p_1 + t_m d_1) / (p_2 + t_m d_2))^{0.5}. \quad (5b)$$

Since quantity of the material m_3 is assumed to be a linear function of amount of the final goods, it is simply given by (5c),

$$m_3 = (a - p_4). \quad (5c)$$

From the above equations, the firm's cost C is obtained,

$$C = 2A^{-1.25} (a - p_4)^{1.25} (p_1 + t_m d_1)^{0.5} (p_2 + t_m d_2)^{0.5} + (a - p_4) ((p_3 + t_e d_3) + F). \quad (6)$$

Thus, the firm's profit function is rewritten as equation (7):

$$Y_M = (a - p_4) ((p_4 - t_g d_4) - (p_3 + t_e d_3)) - 2(a - p_4)^{1.25} A^{-1.25} (p_1 + t_m d_1)^{0.5} (p_2 + t_m d_2)^{0.5} - F. \quad (7)$$

2.2. Determination of the factory's location and price of the final good

From the equation (7) it is possible to derive the profit-maximizing location (X, Y) and

the price P_4 . A method to obtain them is to use a usual numerical calculation. In this case, however, the gradient dynamics which is shown by Puu (1998) is appropriate method since the possibility to derive the solution becomes higher. The essence of this method is that first, an initial value set is given to x_n , y_n , and p_{4n} in the following equations (8a, b, c) as a temporal solution, and obtain the values of x_{n+1} , y_{n+1} , and p_{4n+1} by calculations indicated by the three equations (8a,b,c). And then, the same calculation is iterated until a given tentative solution can be approximately judged as the solution: If the values of $(x_{n+1}, y_{n+1}, p_{4n+1})$ in equations (8a, b, c) become approximately the same as those of (x_n, y_n, p_{4n}) , the values can be admitted as the solution.

$$x_{n+1} = x_n + j * \partial Y_M / \partial x, \quad (8a)$$

$$y_{n+1} = y_n + j * \partial Y_M / \partial y, \quad (8b)$$

$$p_{4n+1} = p_{4n} + j * \partial Y_M / \partial p_4, \quad (8c)$$

where j is the width of a step and n shows the number of the calculation, and $\partial Y_M / \partial x$, $\partial Y_M / \partial y$, and $\partial Y_M / \partial p_4$ are given by equations (9a), (9b), and (9c),

$$\partial Y_M / \partial x = (a - p_4) (-t_g(x/d_4) - t_e(x/d_3) - A^{-1.25} (a - p_4)^{1.25} t_m [\{ (p_2 + t_m d_2)^{0.5} / (p_1 + t_m d_1) \}^{0.5}]$$

$$(x - x_1)/d_1 + \{ (p_1 + t_m d_1)^{0.5} / (p_2 + t_m d_2) \}^{0.5} (x + x_2)/d_2 = 0 \quad (9a)$$

$$\partial Y_M / \partial y = (a - p_4) (-t_g((y - y_4)/d_4) - t_e((y - y_3)/d_3) - A^{-1.25} (a - p_4)^{1.25} t_m [\{ (p_2 + t_m d_2)^{0.5} / (p_1 +$$

$$t_m d_1) \}^{0.5}] (y + y_1)/d_1 + \{ (p_1 + t_m d_1)^{0.5} / (p_2 + t_m d_2) \}^{0.5} (y + y_2)/d_2 = 0 \quad (9b)$$

$$\partial Y_M / \partial p_4 = a - 2 p_4 + t_g d_4 + p_3 + t_e d_3 + 2.5 A^{-1.25} (p_2 + t_m d_2)^{0.5} (p_1 + t_m d_1)^{0.5} (a - p_4)^{0.25} = 0.$$

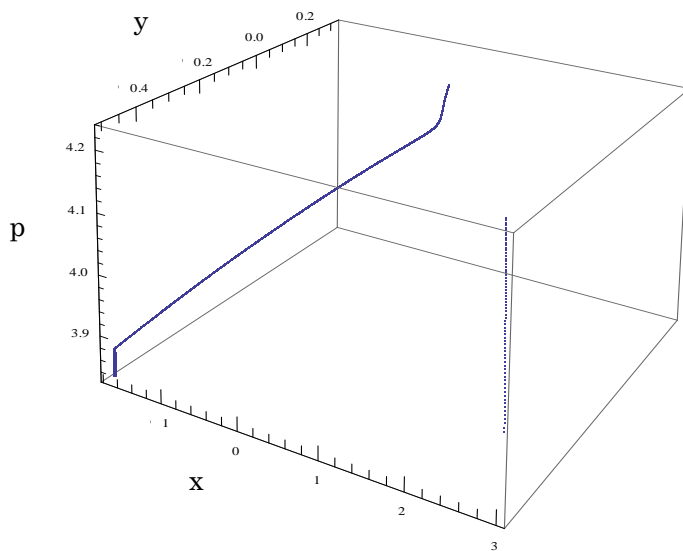
$$(9c)$$

For example, assigning following values to the parameters¹, $(x_1=3, y_1= - 0.5)$, $(x_2= -$

¹ The values for the parameters are selected to be solved easily by a usual numerical calculation method.

$(x_2=1.73, y_2=-0.5)$, $(x_3=0, y_3=-1.5)$, $(x_4=0, y_4=1)$, $p_1 = 2$, $p_2 = 0.1$, $p_3 = 0.2$, $t_m = 0.11$,
 $t_e = 0.01$, $t_g = 0.225$, $a=5.5$, $A=1$, $F=0$, the optimal location and price is obtained by this
 method as $(X=1.732, Y=-0.5, P_4=3.85)$. Figure 2 shows a locus from the first tentative
 solution to the final solution. In this case, the amount of production $Q_S=1.65$, the
 materials $m_1=0.372$, $m_2=9.359$, and the profits of the firm Y_M is 3.564.

Figure 2 A locus to the solution



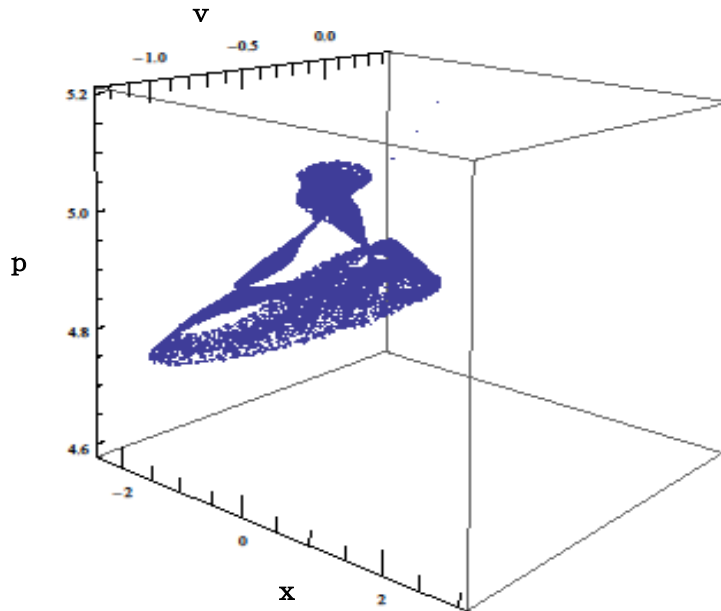
Now, it is not always possible to identify directly the profit-maximizing location (X, Y) and the price P_4 because chaotic phenomenon often emerges in the process of obtaining the solution. When chaotic phenomenon appears, the solution is hidden by this phenomenon. Thus, this case becomes troublesome to reach the solution.

Let us concretely drive a chaotic phenomenon by the gradient dynamics, changing the parameters' value, $a=7.5$, $p_3 = 0.05$, $t_e = 0.044$, $t_g = 0.125$, $a=7.5$, $M_3(0,-0.8)$, chaotic phenomenon appears near at M_2 . Figure 3 shows this chaotic phenomenon.

When a chaotic phenomenon emerges in the calculation process, additional calculation is needed to obtain the solution; it is necessary in this case to derive the firm's profits at many points in the range of the phenomenon and to compare the obtained profits in order to specify approximately the optimal location site and price of the finished goods. Although this chaotic phenomenon seems to be

troublesome for the firms that search the best location point, the phenomenon may provide useful information to the firms. The next subsection explains the usefulness of these chaotic phenomena.

Figure 3 A chaotic phenomenon in the area near point M_2



2.3. Setting prospective area for derivation of the second best location of a factory

Chaotic phenomenon shown in Figure 3 can be interpreted from the economic viewpoint as follows: If the firm decides the location site of the factory and price of the goods in the sphere of the chaotic phenomenon, the firm's profits may not so decrease from the maximum level because the optimal solution is contained in this sphere. It can be, therefore, considered that the range where the phenomenon occurs indicates a kind of a *prospective area* for a possible factory's location. That is, the firm can limit the space area in which the firm search the second best location sites in a large geographical space; the firm can reduce significantly the searching costs of derivation of the factory's location site. Chaotic phenomenon, indicating the prospective area in large geographical area, may provide the manufacturers with useful information when the firms do not have adequate information about many sites in a large space.

It is considered that even if the firm could identify the optimal site for the factory, it might not establish a factory at that place by some reasons. For instance, the place has been occupied by another firm, or land price is too expensive. In these cases, the firm has to search the second best sites around the optimal place. In this searching, chaotic phenomenon can be used for squeezing the spatial range to be searched: The firm can easily find out the second best sites around the best point

in a relatively short period. Chaotic phenomena could be useful for alleviating the firms' location problem.

3. Role of the urban system in a firm's decision making of location

If the prospective area is completed, a firm sets about selecting *a potential region* among regions covered by *the prospective area*. In the selection of this region, the firm can consider the location issue in a broader perspective: Because within the prospective area the firm's profits are not so different, a firm may incorporate many location factors other than profit level such as workers' welfare and environment of areas into its location decision. That is, within the prospective area, many social location factors influence the firm's location decision-making. It is natural in this situation to consider that the social and economic characteristics of the region and the level of the performances achieved in the region affect the firm's selection of the region in the prospective area.

This paper proposes that because the urban system influences the social and economic performance of the region, the structure of the urban system should be incorporated into the firm's location factor. It is said at the same time that the regional government should pay more attention to the urban system laid in the region to invite the firms to the region.

To verify that the urban system affects the region's social and economic performance and it is an important location factor for the firms as well as the regional governments, this section examines the relationships between the urban systems laid in regions and regions' performances which are revealed by using the concept of the social health².

Using the data obtained in Japan, this section examines the relationships between the spatial structure of the urban system and social health achieved in 47 prefectures in Japan by the following three steps;

- (1) Derivation of the numerical index that reveals the characteristic of the urban system,
- (2) Estimation of the regions' social health estimated by several items,
- (3) Examination of the relationships between the indexes and the regions' social health.

3.1. Numerical index of the urban system structure

1) Derivation of Urban System Index

The features of the urban system laid in each prefecture are derived from two points of view, the distribution of the urban population and the density of cities in urban system laid in a region. Then, these two features are uniformed to *an urban system index* which reveals the region's characteristic.

² It has been shown theoretically that the difference of the structure of the urban systems make difference in the performances achieved in the region (Ishikawa, 2010).

(1) Divergence of urban population distribution toward the largest city

Coefficient of the divergence (CD) that indicates the divergence of the population distribution toward the primary city in a region is derived as follows (Sheppard, 1982).

Assuming there are N cities in a region. Let p_r denote the population share of a city for all urban population in the region. Then, equation (10) is established,

$$1 = \sum_{r=1}^N p_r \quad (10)$$

If there is no *a priori* information on the cities, it is rational to infer that the every city has the same share, $p_r=1/N$. This inference is derived by maximizing equation (2) in the subject to the equation (A_1)

$$H = - \sum_{r=1}^N p_r L_N(p_r) . \quad (11)$$

In the real world there is *a priori* information on the cities. Thus, let r indicates the rank of a city according to its population size, and multiplying the value of $\log_e(r)$ by its share as a weigh and then summing up these values. Dividing it by N gives equation (12). The value of CD obtained by equation (12) is considered as the coefficient of divergence of the population distribution to the primary city in the region.

$$CD = (1/N) \sum_{r=1}^N p_r L_N(r) \quad (12)$$

If population of the region is distributed equally between cities, the coefficient of divergence is given by the equation (13).

$$CD = N^{-2} \sum_{r=1}^N L_N(r) \quad (13)$$

The value of CD is used as an index that indicates the characteristics of the distribution of urban population in an urban system. As the distribution of urban population becomes to diverge toward the largest city of the urban system, the value of CD lowers.

(2) Spatial convergence of city distribution in a region

The urban system is examined from the viewpoint of the spatial convergence of the city distribution

in a region. The spatial convergence of the city distribution (SC) in a region is derived by using the nearest neighbor analysis as follows.

Let us assume that there are N_i ($i=1, 2, 3 \dots N$) cities in a region of which land area is M . The distance from a city N_1 to the nearest city is denoted as d_1 . This distance, d_1 , is named as the least distance of the city N_1 . The least distance is obtained for each of cities N_i ($i=1, 2, 3 \dots N$), the average least distance (AD) of cities in the region is derived as equation (14),

$$AD = (1/N) \sum_{i=1}^N d_i \quad (14)$$

The spatial convergence of city distribution in a region is expressed by equation (15),

$$SC = AD / (2 (N/M)^{0.5}) \quad (15)$$

As the cities in a region locate more closely each other, the value of SC becomes smaller. The SC's value is used to specify a characteristic of the urban system laid in a region.

(3) Derivation of the urban system index

Both values of CD and SC become smaller when the distribution of urban population diverges to the largest city and the distances of between cities become closer in the region. Hence, using these values, it is possible to construct an index which shows the characteristic of the spatial structure of the urban system. This index is called as *Urban System Index* (USI), which is derived by equation (16),

$$USI = ((\alpha CD)^2 + (\beta SC)^2)^{0.5} \quad (16)$$

where α and β are positive parameters. When the value of the USI is lower, it means that the structure of the urban system has a characteristic of converging in terms of population distribution and location of cities. On the other hand, the high value of the USI means that the structure of urban system has a characteristic of leveling in terms of population distribution and location of cities. In the rest of the paper, USI is used as the index that indicates the characteristic of the urban system.

2) Urban System Index of 47 prefectures in Japan

There are 47 prefectures in Japan. It may be said that an urban system is laid in the individual prefectures. Using the equation (16), USI of each prefecture in 2008 can be derived from the data of CD (the data of all cities' population in 47 prefectures in 2008) and SC (the data of all cities' least

distances in all prefectures in 1990 since the data of the distance is stable in the long time, the data of 1990 is used here.). Table 1 shows the values of CD, SC, and USI for 47 prefectures. In the derivation of USI, the parameters in the equation (16) are assumed as $\alpha = 20, \beta = 1$.

Table 1 The Urban System Index of 47 prefectures in Japan

No.	Prefecture	CD	SC	USI
1	Hokkaido	0.0326	1.3861	1.5325
2	Aomori	0,102	2,466875	3,20110
3	Iwate	0,086	2,732682	3,2289
4	Miyagi	0,054	1,986952	2,2614
5	Akita	0,087	2,651569	3,1715
6	Yamagata	0,089	1,587727	2,3852
7	Fukushima	0,09	2,117017	2,7788
8	Ibaragi	0,074	1,491258	2,10101
9	Tochigi	0,084	1,321813	2,1376
10	Gunma	0,101	1,750309	2,6577
11	Saitama	0,044	1,334769	1,5987
12	Chiba	0,051	1,867061	2,1275
13	Tokyo	0,024	1,083915	1,1854
14	Kanagawa	0,045	1,550007	1,7923
15	Niigata	0,063	1,802285	2,1990
16	Toyama	0,073	1,124717	1,8429
17	Ishikawa	0,073	3,191603	3,5096
18	Fukui	0,098	2,393305	3,0934
19	Yamanashi	0,102	1,379157	2,4624
20	Nagano	0,074	1,809893	2,3379
21	Gifu	0,070	1,910697	2,3687
22	Shizuoka	0,059	1,941794	2,2722
23	Aichi	0,042	1,347925	1,5882
24	Mie	0,084	2,141469	2,7218
25	Shiga	0,101	1,682657	2,6290
26	Kyoto	0,049	1,964006	2,1949
27	Osaka	0,044	1,216331	1,5012
28	Hyogo	0,052	2,036104	2,2863
29	Nara	0,092	1,337015	2,2744
30	Wakayama	0,074	4,035519	4,2983
31	Tottori	0,135	3,504247	4,4237
32	Shimane	0,115	3,067504	3,8340
33	Okayama	0,066	2,496594	2,8240
34	Hiroshima	0,053	2,334539	2,5639
35	Yamaguchi	0,093	3,10841	3,6224
36	Tokushima	0,103	3,631774	4,1753
37	Kagawa	0,09	1,570651	2,3889

38	Ehime	0,072	1,942757	2,4182
39	Kochi	0,066	3,500824	3,7414
40	Fukuoka	0,049	1,523937	1,81184
41	Saga	0,115	2,40255	3,3259
42	Nagasaki	0,076	2,456682	2,8888
43	Kumamoto	0,051	2,733707	2,9177
44	Oita	0,067	2,895773	3,1907
45	Miyazaki	0,089	2,916389	3,4166
46	Kagoshima	0,055	2,651677	2,8707
47	Okinawa	0,093	1,412201	2,3353

3.2. Estimation of social health of 47 prefectures in Japan

Social health of each prefecture in Japan is estimated in terms of seven items; (a) economic base, (b) education, (c) dwelling, (d) health, (e) welfare, (f) safety, (g) social unrest. And each of seven items is composed by several elements which are listed in Appendix. Social health of each prefecture is calculated by following procedures.

Social health of individual prefectures is build up by the scores of the above seven items³. The score of an element E of an item r in a prefecture i , S_{rEi} ($r=a, b, \dots, g$; $E=r_1, r_2, \dots, r_n$; $i=1, 2, 3, \dots, 47$; r indicates item; f indicates a factor which consists r item; i shows prefecture) is derived by equation (17).

$$S_{rEi} = (X_{rEi} - AV_{rE}) / ST_{rE} \quad (17)$$

($r = a, b, \dots, g$; $E = r_1, r_2, \dots, r_n$; $i = 1, 2, \dots, 47$)

where X_{rEi} is a datum value of element E in r item of prefecture i . AV_{rE} is the mean value of the element E in r item, ST_{rE} is the standard deviation of the element E of r item. Score of r item of prefecture i ($i=1, 2, \dots, 47$) is obtained by equation (18)

$$S_{ri} = (1/n) \sum_{E=r_1}^{r_n} S_{rEi} \quad (18)$$

($r = a, b, \dots, g$; $i = 1, 2, \dots, 47$)

Social health (SH) of prefecture i is made up by the scores of the seven items; the value of the social health by obtained by equation (19).

³ All data is based on “Social indications by prefecture” Statistics Bureau, Ministry of internal affairs and communications, Japan (2011)

$$SH_i = (1/7) \sum_{r=a}^g S_{ri} \quad (19)$$

(i=1,2,...47)

Scores of the seven items and social health of 47 prefectures are indicated in Table 2.

Table 2 Scores of items and social health of 47 prefectures in Japan

Prefecture	Economic base	Education	Dwelling	Health	Welfare	Safety	Social unrest	Social health
Hokkaido	-0,5341	0,605482	0,31498	0,72302	0,4272	0,1203	0,12035	0,1579369
Aomori	-0,8877	0,196016	0,06229	-0,1804	0,7302	-0,089	-0,0888	-0,015901
Iwate	-0,7406	0,267378	-0,161	-0,1082	-0,262	0,3738	0,37377	-0,076508
Miyagi	-0,2392	0,245402	-0,0015	-0,6085	-0,801	0,0047	0,00469	-0,201974
Akita	-0,5714	0,281897	0,50981	0,12453	0,6935	0,4936	0,4936	0,2617918
Yamagata	-0,455	0,297927	0,24969	-0,4101	-0,293	-0,017	-0,0167	-0,05266
Fukushima	-0,2929	-0,19249	0,00988	-0,1889	-0,677	0,6778	0,67781	-0,078809
Ibaragi	0,50222	-0,20327	-0,4303	-0,7005	-1,037	-0,335	-0,335	-0,388862
Tochigi	0,31497	-0,19294	-0,1242	-0,4792	-1,239	-0,77	-0,77	-0,365233
Gunma	0,4072	-0,34228	0,04396	-0,3666	-0,613	-0,288	-0,2879	-0,213944
Saitama	0,5766	-0,29667	-0,5955	-1,2893	-1,639	-0,314	-0,3144	-0,536352
Chiba	0,85972	0,074178	-0,5741	-0,9258	-1,625	0,0641	0,06412	-0,326373
Tokyo	1,50449	0,756757	-0,4638	0,4346	-0,012	-0,243	-0,2428	0,2891645
Kanagawa	0,80846	0,103219	-0,7603	-1,0246	-1,204	-0,409	-0,4086	-0,376051
Niigata	-0,0259	-0,07173	0,39697	-0,2715	-0,371	0,5362	0,53619	0,0542602
Toyama	0,2631	-0,30194	0,35522	0,01069	-0,257	0,9618	0,96178	0,1577868
Ishikawa	-0,0456	0,124381	0,42154	0,02255	-0,083	0,9698	0,9698	0,230044
Fukui	0,06327	-0,2663	0,52452	-0,2638	0,1974	0,2964	0,29641	0,1302644
Yamanashi	0,0038	0,188246	0,15172	-0,0744	0,2209	-0,569	-0,5692	0,035173
Nagano	0,23445	-0,44702	0,50994	-0,3053	-0,211	-0,284	-0,2844	-0,048605
Gifu	0,36025	-0,43951	0,32432	-0,639	-0,833	0,0646	0,06465	-0,178033
Shizuoka	0,77199	-0,79904	-0,0981	-0,9237	-1,347	-0,092	-0,0923	-0,407769
Aichi	1,69099	-0,24711	-0,2891	-1,011	-1,126	-0,309	-0,3086	-0,314072
Mie	0,58228	-0,29559	-0,2121	-0,5225	-0,619	-0,12	-0,12	-0,189973
Shiga	0,46197	0,066235	-0,1519	-0,9748	-0,782	0,0064	0,0064	-0,185594
Kyoto	0,3627	0,904434	0,0815	0,11052	0,0994	0,131	0,13096	0,283651
Osaka	0,30552	-0,22915	-0,3621	-0,0504	-0,088	-1,071	-1,0715	-0,275277

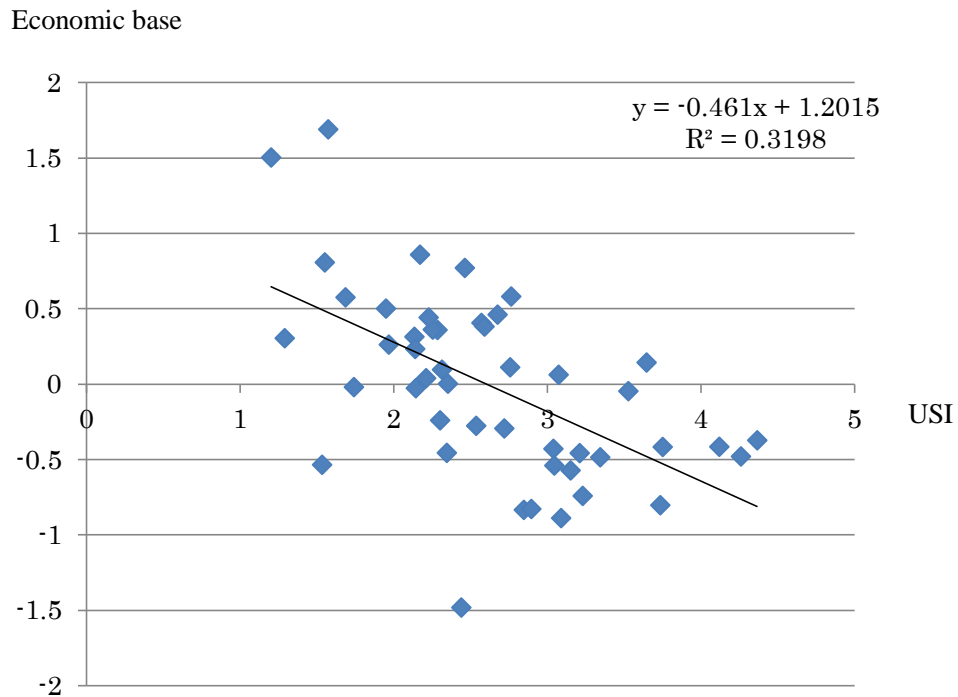
Hyogo	0,44302	-0,0332	0,00952	-0,5288	-0,504	0,2618	0,26184	-0,156139
Nara	0,04017	0,21935	0,09594	-0,3287	-0,529	-0,009	-0,009	-0,024406
Wakayama	-0,3718	-0,31203	-0,1105	0,53286	0,674	-0,698	-0,6979	-0,024257
Tottori	-0,4786	0,33481	0,42856	0,34943	1,3939	0,1993	0,19928	0,4016482
Shimane	-0,4159	0,680282	0,45458	0,7841	1,0957	0,4627	0,46272	0,5268948
Okayama	0,11259	0,084917	-0,0626	0,35207	-0,104	0,1141	0,11409	-0,01962
Hiroshima	0,38273	-0,07315	0,02329	0,19995	-0,084	0,1229	0,12291	0,0528726
Yamaguchi	0,14424	0,114507	0,15113	0,46324	0,4454	0,0069	0,00688	0,2411563
Tokushima	-0,4146	0,235505	-0,2051	1,0854	0,9501	0,5026	0,5026	0,350007
Kagawa	0,09688	-0,31289	0,08268	0,18689	0,2383	0,1731	0,17307	-0,001101
Ehime	-0,2755	-0,07951	-0,2304	0,33731	0,4307	-0,101	-0,1011	-0,012447
Kochi	-0,8023	0,241263	0,23549	1,58716	1,5612	-0,404	-0,4036	0,3152828
Fukuoka	-0,0187	-0,17413	-0,404	0,69839	0,3575	-0,738	-0,7377	-0,13451
Saga	-0,4282	-0,29224	-0,0003	0,71007	0,5886	0,2593	0,25929	0,1526213
Nagasaki	-0,8333	-0,12967	-0,1046	1,00878	1,2978	0,3388	0,33875	0,2923275
Kumamoto	-0,5389	0,12158	-0,2791	0,70208	0,5587	0,4606	0,46062	0,1951235
Oita	-0,4568	0,044558	-0,0569	0,37063	0,8741	-0,069	-0,0694	0,1072699
Miyazaki	-0,4844	-0,29376	0,36561	0,31078	0,9605	-0,337	-0,3369	0,0922719
Kagoshima	-0,8272	0,292688	-0,0097	1,07491	1,3794	0,191	0,19104	0,3265861
Okinawa	-1,481	-0,62855	-0,137	-0,0668	0,8263	-0,347	-0,3474	-0,156854

3.3. Relationships between urban system and prefectures' performances

1) Relationship between the urban system and economic performance of region

First, let us examine the relationship between urban system indexes (USI) and score of the economic base of prefectures in Japan. As shown in Figure 3, there is clear relationship between the structure of urban system laid in a prefecture and economic performance achieved in the prefecture. As the urban system has characteristic of converging in terms of population distribution and location of cities, its economic performance becomes higher.

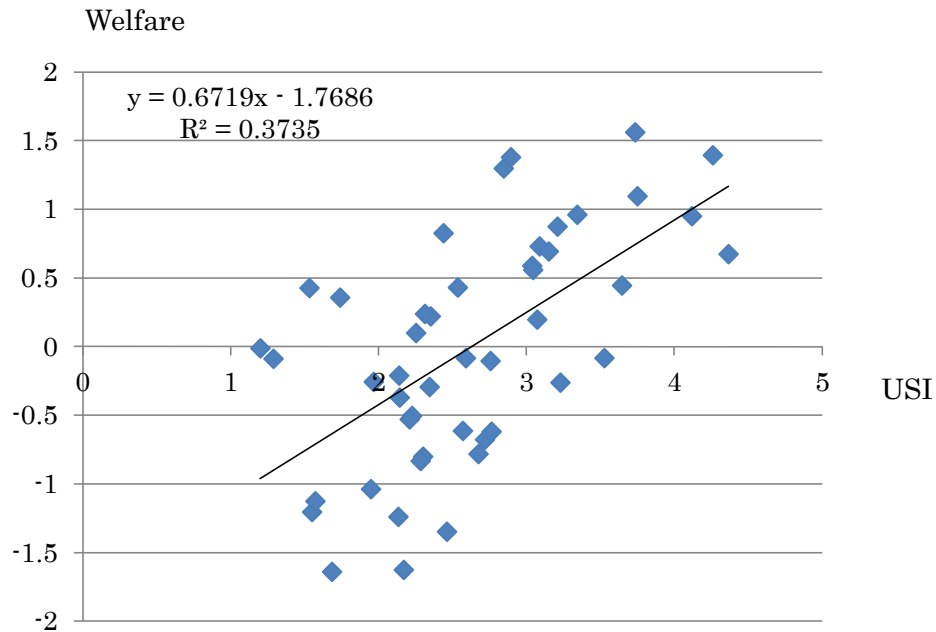
Figure 3 Relationship between USI and economic performance of prefectures



2) Relationship between the urban system and welfare of region

Secondly, the relationship between the urban system indexes and scores of the welfare of prefectures in Japan is examined. As shown in Figure 4, there is clear relationship between the structure of urban system laid in a prefecture and social performance achieved in the prefecture. As the structure of urban system laid in prefecture has leveling characteristics in terms of population distribution and location of cities, prefecture's welfare performance becomes higher.

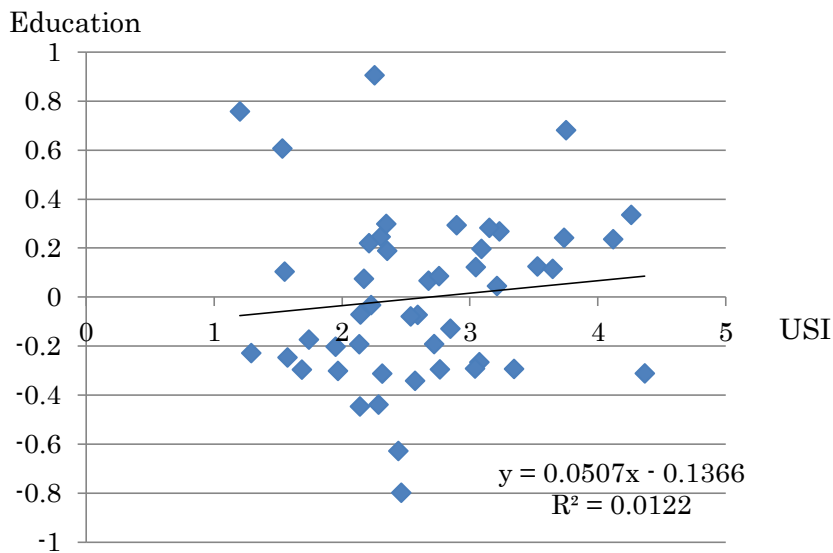
Figure 4 Relationship between USI and welfare of prefectures



3) No relationship between the urban system and education of region

Thirdly, the relationship between urban system indexes and scores of education of prefectures in Japan is examined. There is no clear relationship between USI and scores of education of prefectures. Figure 5 shows the relationship.

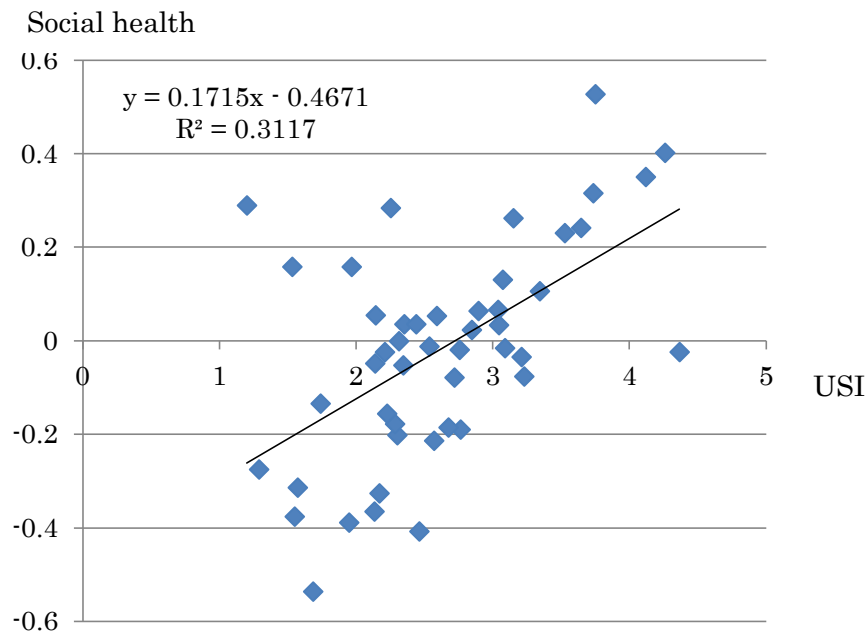
Figure 5 Relationship between the urban system and education of prefecture



4) Relationship between the urban system and social health of region

Finally, let us examine the relationship between USI and social health which is consisted of the seven items. Figure 6 shows this relationship. As the structure of urban system has characteristic of leveling in terms of population distribution and location of cities, the social health becomes higher.

Figure 6 Relationship between the urban system and social health of prefecture



3.4. Urban system as a location factor

Based on the above analysis, it could be say that if the firm makes much of the production efficiency of the factory, within the prospective area it should select the region of which urban system has characteristic of converging. On the other hand, if the firm considers the region's welfare level as most important factor in the selection of a region, it should select the region of which the urban system has characteristic of leveling. Finally, when the firm pays equally its attention to both the production efficiency of a factory and the level of the welfare of a region, it may choose the region of which the urban system has an intermediate characteristic, that is, the value of USI is in the average value range.

Because the urban system in a region influences the economic and social performance achieved in the region, the firms should pay their attention to the urban system when they plan to establish new factories. It is said that the urban system must be considered as an important location factor the firms as well as the regional governments.

4. Concluding remarks

When a firm has a project to build a new factory or to move a factory from existing industrial area to another place, the determination of the factory's location site is the most important in the project. Since a firm does not have enough information of the economic and social characteristics of all potential location areas and sites, the manufacturer cannot determine immediately its location site. A series of steps are taken to decide the final location place. A firm makes range of searching area small step by step toward the final determination; there are two steps in the early determination processes, 1) the determination of a prospective area in a large geographical space and 2) the selection of a region in prospective area. In the first step a chaotic phenomenon, which is appeared in the calculation processes to specify the optimal location site, may be used to identify a prospective area. Utilizing this phenomenon reduces the costs to specify the searching area for the second best location place of a factory. In the second step, the selection of a region in the prospective area for the factory location, the region's economic and social performances achieved in the region play an important role. Because the economic and social performances are affected by the structure of the urban system laid in the regions, the urban system is considered as an important location factor for the firms. This fact also indicates that the urban system is important for the regional governments which plan to attract firms to the area to develop sustainably the regional economy. The regional government should pay attention to the structure of the urban system to attract firms to its region.

Appendix: Elements of the seven items composing the social health

(a)Economic base:

1. Prefectural income per person, ¥1000.
2. Value of manufactured goods shipments, etc, ¥ 100million.
- 3*. Unemployment rate, both sexes.
- 4*. Regional difference index of consumer prices, Tokyo=100.
5. Index of financial potential, prefecture.
6. Starting salary, senior high school graduates, month, male and female, ¥1000.
7. Salary of part-time worker, hour, female, ¥1.

(b)Education:

8. Elementary school pupil, per teacher.
9. Exercise ground area of pupil, elementary schools, per pupil ,m².
10. Entrance capacity index of colleges and universities.
11. Ratio of people having completed up to colleges and universities.%.

(c) Dwelling:

12. Ratio of owned houses, %.
13. Dwelling rooms, per dwelling,
- 14*. Monthly rent, owned by private corporation, per m², ¥1000.
15. Ratio of households covered by city gas supply system, %.
16. Diffusion rate of sewerage, %.
17. Ratio of forest area, %.
18. Area of public parks per capita, m².
19. Ratio of major roads paved, %.
20. Retail stores excluding eating and drinking places etc, per 1000 persons.
21. Eating and drinking places, per 1000 persons.
22. Sports facilities, per 1,000,000 persons

(d) Health:

23. Physicians working at medical establishments, per 100,000 persons.
24. Beds in general hospitals, per 100,000 persons.
25. Dental clinics, per 100,000 persons.
26. Beds for mental diseases, per 100,000 persons.
27. Ambulances clinics, per 100,000 persons.

(e) Welfare:

28. Homes for the aged, per 100,000 persons, 65 years old and over.
29. Rehabilitation facilities for physically disabled persons, per 1,000,000 persons
30. Child welfare institutions, per 100,000 persons.
31. Welfare expenditure per capita, prefecture + municipality, ¥1000.
32. Social welfare expenditure per capita, prefecture + municipality, ¥1000.
33. Social welfare expenditure for aged person per capita 65 years old and over, prefecture + municipality, ¥1000.

(f) Safety:

- 34*. Traffic accidents, per 100,000 persons
- 35*. Persons killed or injured by fires, per 100,000 persons
36. Fire engines and cars existing, per 100,000 persons.
37. Police men, per 1000 persons
- 38*. Recognitions of criminal offences, per 1,000 persons.

39*. Death by accidents, per 100,000 persons.

40*. Soot and smoke emitting facilities.

41*. General dust discharging facilities.

(g) Social unrest:

42*. Cases indicted for drug law, per 100,000 persons

43*. Cases of grievance against pollution, per 100,000 persons.

44*. Rate of divorces, per 1000 persons, %.

45*. Suicides, per 100,000 persons.

46*. Ratio of long-term absences from junior high school students due to refusal to attend school 30 days and more for a school year, per 1000 students.

(The mark "*" denotes that the element of which value is lower, its score becomes higher.)

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