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## Firm's location choices by referring to chaotic phenomenon and the central place system

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Firm's location choices by referring to chaotic phenomenon  
and the central place system

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Abstract

When manufacturing firm projects to construct a factory, the firm searches a factory's location in large geographical area. The manufacturer does not determine immediately its location site since the manufacturer can not have enough information of economic conditions of all potential location sites. Hence, the manufacturer makes sphere of searching area small step by step. In this firm's searching processes, following four steps may be taken: 1) Decision of a prospective region, 2) Selection of a potential area in that region, 3) Choice of an urban district in that area, 4) Determination of a site in the district. This paper proposes that in the first step, chaotic phenomenon that is emerged in the processes of calculation conducted for the determination of the factory's optimal location has the possibility to be used to identify a prospective region; in the second step, the retailers' location system laid in the region plays a significant role in the selection of a potential area in the region. This paper elucidates how a firm finds out step by step a factory's location within large geographical area.

I Introduction

A firm projecting to construct a new factory arranges the quantity and the price of the goods produced in the establishment. At the same time, it needs to decide its location site. For the acquisition of plot and the construction of a factory the firm bears much funds as well as time. Once a factory is constructed at a site, the manufacturer does not easily move it to another. Thus, the factory's location influences the firm's activities for a long time. Decision of a factory's location is always one of important tasks of manufacturers.

Weber (1909) analyzed a firm's location from the viewpoint of production costs. His theory explains how a firm searches the site that minimizes its total production costs. It has provided a robust theoretical standard in firm's decision-making of location.

Viewing recent trend of industrial location in the real world<sup>1</sup>, however, there are at least two facts which are not successfully fitted to the Weber's framework. One is that recent firms divide production processes to some blocs in order to reduce production costs<sup>2</sup>, as a result, characteristics of each production bloc become clear and different from each other. Thus, the sliced bloc wants workers with narrow specific skill, and they move in the long distance to the place where such a suitable workers are supplied<sup>3</sup>. Another is that laborers also move in the long distance to place providing job opportunity for which they make full use of their ability<sup>4</sup>. Being influenced by these factors, recently factory moves across countries to locate at a prospective place.

Corresponding to the above view, this paper, first, suggests that when a manufacturing firm selects the location for a factory within large geographical area, chaotic phenomenon has the possibility to be used to identify a prospective region for the factory's location. Secondly, this paper explains the role of the location system of retailers in a firm's decision of potential area in the region: In this paper the retailers' location system is combined with a firm's location decision, and it is examined how the retailers' location system influences a firm's decision-making of location.

The paper is organized as follow: Section II analyzes a factory's location and price of goods by the gradient dynamics. In Section III the relationships between a factory's location issue and the retailers' location system are examined. Section IV shows four steps that a firm takes in decision-making of location. Section V concludes the analysis and remarks on a regional policy.

## II The role of chaotic phenomenon in a firm's decision of location and price

### 1 Derivation of a firm's profit function

A firm's profit function is derived on the following assumptions. A factory uses two kinds of materials  $m_1$ ,  $m_2$  to produce the final good  $m_3$ . The materials are produced at points  $M_1$  and  $M_2$  which are identified by coordinates  $(x_1, y_1)$ ,  $(x_2, y_2)$ , respectively. They are transported to the factory at point  $L(x, y)$ . Freight rates of them are denoted by  $t_m$ . Their mill prices  $p_1$  and  $p_2$  are given. The price of the final good  $p_3$  is decided by the firm. The finished goods are transported from the factory to the market at point  $M_3$

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<sup>1</sup> Recent trend of industrial location has been analyzed and explained from various viewpoints. For example, see Arndt-Kierzkowski (2001).

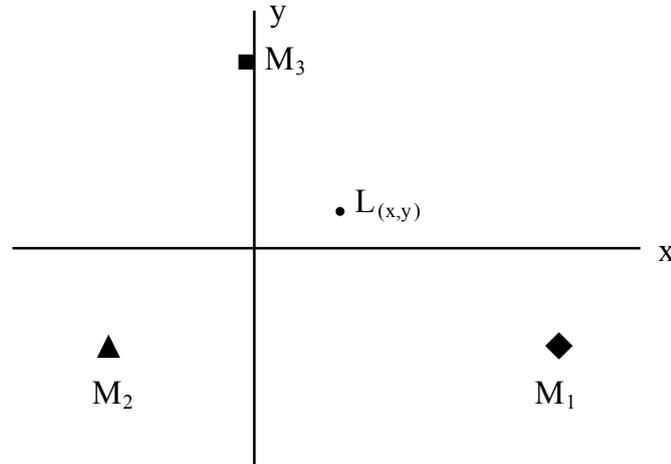
<sup>2</sup> Fragmentation raised from cost completion is explained in detail by Dluhosch (2000).

<sup>3</sup> In relation to fragmentation of production processes, the role of functions which governs the sliced blocs is important in a firm's activity.

<sup>4</sup> Mathur-Stein (2005) examines the effects of laborers' behavior on regional economy.

$(x_3, y_3)$ . The freight rate of the final goods is  $t_g$ . Figure 1 illustrates the geographical relationship between the factory, the market and the materials.

Figure 1 Factory's location in huge space



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.  $A, \alpha$  and  $\beta$  are defined as  $A > 0$ ,  $0 < (\alpha + \beta) < 1$ . Market demand function for the finished goods is given by equation (2):

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

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

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

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

The distance between the factory  $L$  and the market  $M_3$  is given by  $d_3$ :

$$d_3 = ((x - x_3)^2 + (y - y_3)^2)^{0.5}. \quad (3c)$$

If fixed cost is  $F$ , the firm's profits  $Y_M$  is given by equation (4),

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

Noticing the fact that  $Q_s$  is equal to  $Q_d$ , and 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,  $\alpha$  and  $\beta$  are assumed  $\alpha=\beta=0.4$ ):

$$m_1 = A^{-1.25} (a - p_3)^{1.25} ((p_2 + t_m d_2)/(p_1 + t_m d_1))^{0.5}, \quad (5a)$$

$$m_2 = A^{-1.25} (a - p_3)^{1.25} ((p_1 + t_m d_1)/(p_2 + t_m d_2))^{0.5}. \quad (5b)$$

From these equations, the firm's production costs  $C$  is obtained as:

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

Hence, the firm's profits are rewritten as equation (7):

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

## 2 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  $P_3$ . A usual method to obtain them is to differentiate equation (7) by  $x$ ,  $y$ , and  $p_3$ , and then, to solve the three simultaneous equations (8a, b, c) with respect to  $x$ ,  $y$ , and  $p_3$  by a numerical calculation method.

$$\begin{aligned} \partial Y_M / \partial x = & (a - p_3)(-t_g)(x/d_3) - \\ & - A^{-1.25} (a - p_3)^{1.25} t_g [ \{ (p_2 + t_m d_2)^{0.5} / (p_1 + t_m d_1)^{0.5} \} (x - x_1) / d_1 + \\ & + \{ (p_1 + t_m d_1)^{0.5} / (p_2 + t_m d_2)^{0.5} \} (x + x_2) / d_2 ] = 0 \end{aligned} \quad (8a)$$

$$\begin{aligned} \partial Y_M / \partial y = & (a - p_3)(-t_g)((y - y_3)/d_3) - \\ & - A^{-1.25} (a - p_3)^{1.25} t_g [ \{ (p_2 + t_m d_2)^{0.5} / (p_1 + t_m d_1)^{0.5} \} (y + y_1) / d_1 + \\ & + \{ (p_1 + t_m d_1)^{0.5} / (p_2 + t_m d_2)^{0.5} \} (y + y_2) / d_2 ] = 0 \end{aligned} \quad (8b)$$

$$\begin{aligned} \partial Y_M / \partial p_3 = a - 2p_3 + t_g d_3 + \\ + 2.5A^{-1.25} (p_2 + t_m d_2)^{0.5} (p_1 + t_m d_1)^{0.5} (a - p_3)^{0.25} = 0. \end{aligned} \quad (8c)$$

It is not always possible, however, to obtain the solution by a usual calculation. For example, if assigning following values to the parameters,  $(x_1=3, y_1=-0.5)$ ,  $(x_2=-1.73, y_2=-0.5)$ ,  $(x_3=0, y_3=1)$ ,  $p_1=0.25$ ,  $p_2=2$ ,  $t_m=0.11, t_g=0.225$ ,  $a=5$ ,  $A=1, F=0$ , the optimal location and price can not be obtained by a usual calculation<sup>5</sup>. In this case, the gradient dynamics can be an alternative method which is shown by Puu (1998). The essence of this method is that first, an initial values set is given to  $x$ ,  $y$ , and  $p_3$  in equations (9a, b, c) as a temporal solution, and calculations indicated by these three equations are iterated until a given tentative solution can be approximately judged as the solution: When the values of  $(x_{n+1}, y_{n+1}, p_{3n+1})$  in equations (9a, b, c) become approximately the same as those of  $(x_n, y_n, p_{3n})$ , the values set can be admitted as the solution.

$$x_{n+1} = x_n + j * \partial Y_M / \partial x, \quad (9a)$$

$$y_{n+1} = y_n + j * \partial Y_M / \partial y, \quad (9b)$$

$$p_{3n+1} = p_{3n} + j * \partial Y_M / \partial p_3, \quad (9c)$$

where  $j$  is the width of a step, and  $n$  shows the number of the calculation. This method often gives rise to chaotic phenomenon around solution and saddle points. When chaotic phenomenon emerges, the solution is hidden by this phenomenon, it is necessary in this troublesome case to derive firm's profits at several points in the range of the phenomenon and to compare them to approximately specify the optimal site.

Let us concretely derive the optimal location and price by the gradient dynamics, assigning the above values to the parameters. In Figure 2A) the dotted line shows a

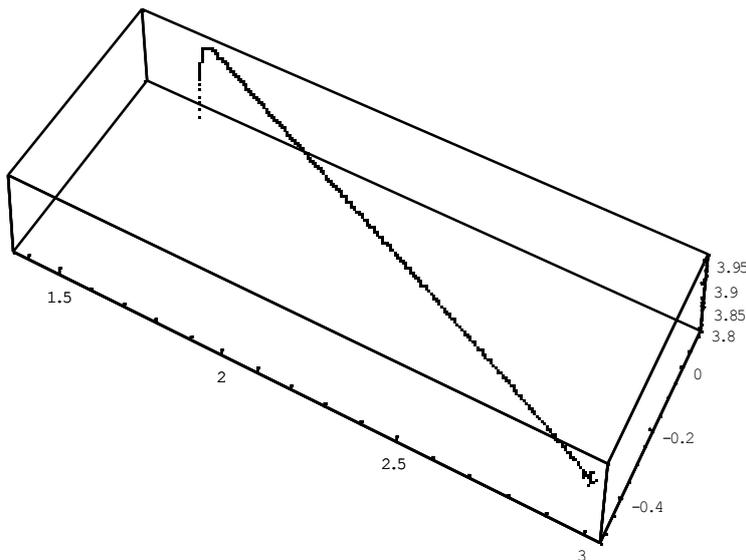
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<sup>5</sup> The values for the parameters are selected not to be solved easily by a usual numerical calculation method.

route of the temporal solutions from the first tentative solution to the small area in which the solution is contained. A chaotic phenomenon appears around point  $M_1$ . Figure 2 B) shows, changing the value of  $j$ , another larger chaotic phenomenon appeared around point  $M_1$ . In this case, by comparing the firm's profits at some points in this phenomenon, it is found that when the firm settles the factory at  $M_1$  and sets the price as 3.89, the firm obtains the maximum profit,  $Y_M=2.10$ . In addition, the materials used are derived as  $m_1=3.622$ ,  $m_2=0.359$ , respectively, and quantity of the final good  $m_3$  is 1.11.

If the parameter  $A$ , which indicates the efficiency of the factory, increases from 1 to 2.62, as shown in Figure 3, a chaotic phenomenon occurs around the market. In this case the factory locates at the market and the price is determined as 3.026, and the maximum profit of 4.32 is achieved. At this factory's location, the used materials and the produced good are changed to  $m_1=1.34$ ,  $m_2=0.367$ , and  $m_3=1.97$ , respectively. An increase of the productivity of the factory leads the factory toward the market<sup>6</sup>.

Figure 2 A) A path to chaotic phenomenon surrounding the solution



<sup>6</sup> This paper has not examined the condition and the range of parameters that generates a chaotic phenomenon. This issue will be investigated in the next analysis.

Figure 2 B) Chaotic phenomenon around point  $M_1$

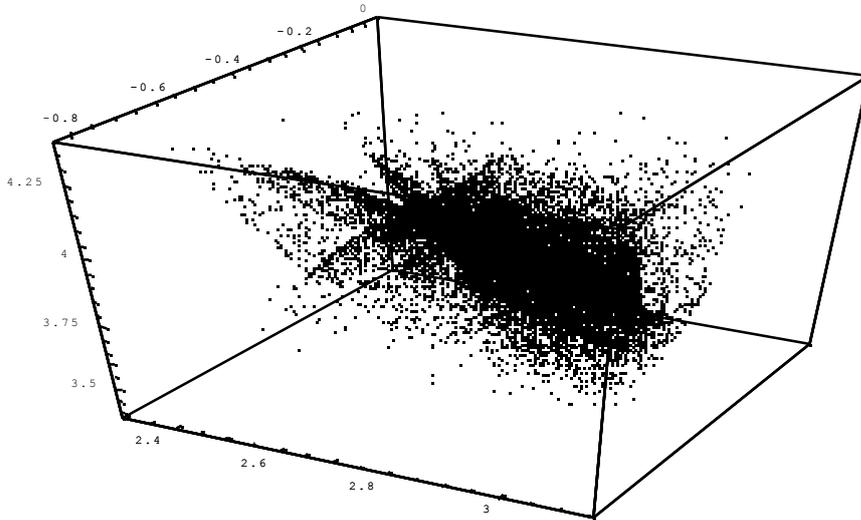
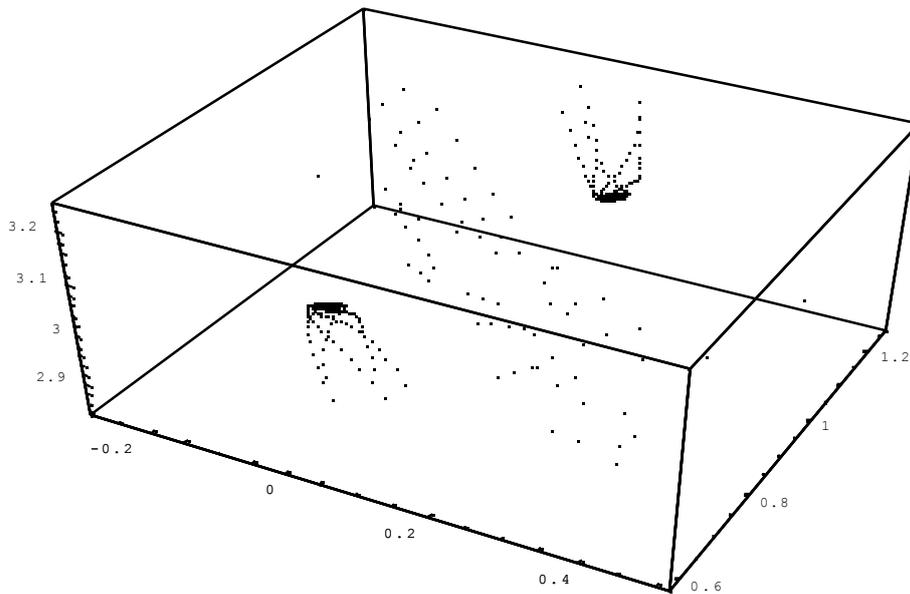


Figure 3 Chaotic phenomenon around the market place



### 3 Usefulness of chaotic phenomenon in the firm's location decision-making

Chaotic phenomena shown in the above figures can be interpreted from the economic viewpoint as follow<sup>7</sup>: This phenomenon defines the sphere that contains the optimal

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<sup>7</sup> Puu (1998) uses chaos phenomena to explain why location network of modern factories tends to change in a relatively short time.

location and price. If a firm would decide location and price in this sphere, the obtained level of profits may not so decrease from the maximum one. It can be, therefore, considered that the range where the phenomenon occurs suggests a prospective region for a factory's location. Chaotic phenomena may provide manufacturer with useful information when the firms search factory's location in vast geographical area.

It may be also considered that even if a firm could identify the optimal site for its factory, it might not establish a factory at that site by some reasons. For instance, the site has been occupied by another land user, or land price is too expensive. In these cases, the firm has to look for the second best sites around the optimal point. In this situation, chaotic phenomena can be used for squeezing the range to be searched: The firm can easily find the second best sites around the best point in a relatively short period. Chaotic phenomena could be useful for alleviating the firms' location problem.

### III The central place system as the general location determinant

If the prospective region is completed, a firm sets about selecting a potential area for a factory within this region. In this selection, the firm can consider location issue in a broader perspective: Besides profits level, other location factors including workers' welfare can be incorporated into the firm's location decision. This paper proposes that the central place system is able to play an important role in a firm's selecting of a potential area within the prospective region<sup>8</sup>.

#### 1 The central place system supporting laborers and firms

Laborers turn into consumers after they leave factories. They need various sorts of goods to sustain their lives. All goods are not supplied by a single retailer, but they are provided by many retailers scattering in area. Each retailer participates to location system with many retailers: This participation increases quantity purchased and retailer's profits due to the reduction of transport costs borne by consumers. Location system of the retailers is called the central place system. It can be said that since the central place system sustains laborers' lives, this system is indispensable for factory's location.

In a region there are many central place systems which have different economic performances. Difference of their performances attracts the attention of the firms which plan to construct factories. Hence, structure of the central place system is considered as an important location factor for manufacturers.

The studies of the central place systems have been compiled on the memorable works

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<sup>8</sup> Capello (2007) stresses the importance of the role of urban system in firm's location choices in the context of local development.

of Christaller (1933) and Lösch (1942). Reviewing a literature of the systems from the viewpoint of economics shows that Christaller's theory is founded in quasi-monopolistic economic situation, while Lösch's is formed on the monopolistic competition<sup>9</sup>. This paper, using Christaller's framework, builds two central place systems and inquires their economic performances. The performances are measured in terms of total quantity demanded and total profits of retailers. The revealing the difference in the performances makes it clear why the manufacturers should pay their attention to the structure of the systems that lay on a region.

## 2 Spatial structures of two central place systems

Two central place systems which have different spatial structure are introduced to examine how the different structures affect economic performances achieved in the systems: One system is constructed by the supply principle; another is constructed by the transport principle.

Figure 4 shows the central place system formed by the supply principle. Point L forms the largest central place. This place sells four kinds of goods which are sold individually in four markets with different sizes according to the character of goods. Of four markets the largest market is shown by the bold lines. Points  $M_1 - M_6$ , which carry three kinds of goods, are settled at the six vertices of the largest market; they are medium central places. Biggest markets of them are shown by the thin lines. Points  $S_1 - S_6$ , which sell two kinds of goods, locate at the six vertices of market areas of the medium central places. They are small central places. Smallest central places H, which are not shown in Figure 4, sell one kind of goods.

Figure 5 describes the central place system formed by the transport principle. Point L is the largest central place. Location and market of this place are the same as those of the supply system. Medium central places, however, are settled at the mid-points of the six sides of the largest market. These central places are shown by points  $M_1 - M_6$ . As a result, both their location and market pattern are different those of the supply system. This market formation is shown by the thin lines. Smaller central places S and H are also sited at the mid-points of the sides of the market areas of the higher-order central places. Points  $S_i$  ( $i=1, 2, \dots, 8$ ) show small central places, their location and market size are also different from those of the supply system.

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<sup>9</sup> The relationship between competition types in market and central place systems is examined by Ishikawa-Toda (2000).

Figure 4 Central place system formed by the supply principle

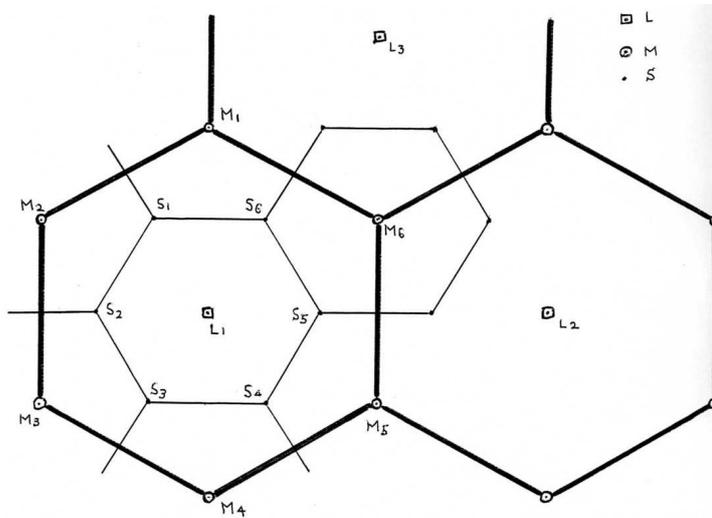
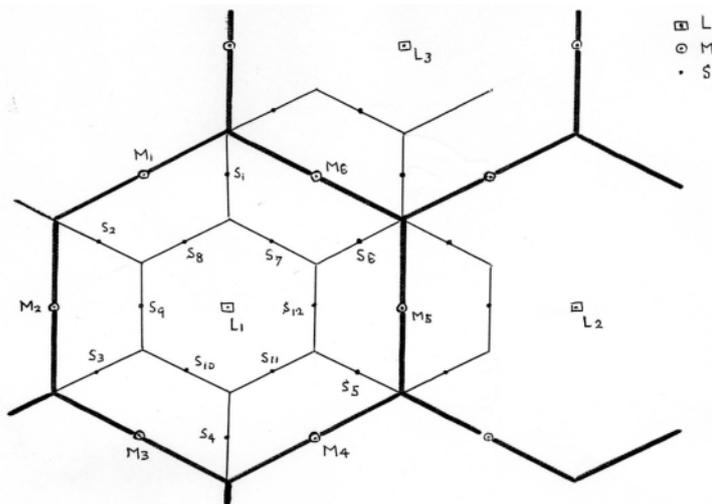


Figure 5 Central place system based on the transport principle



### 3 Economic performances achieved in the central place system

#### 1) Basic assumptions

Quantity demanded and retailers' profits achieved in the central place system are derived under following assumptions<sup>10</sup>.

- (1) Consumers live evenly in area. They have the same demand function:

<sup>10</sup> Social surplus could be used as a measure of economic performance.

$$q = ba - p_r - tu \quad (10)$$

where  $q$  is quantity demanded,  $a$  is the maximum reservation price,  $b$  is the coefficient attached to  $a$ . According to the  $b$ 's value, the kind of good is specified.  $p_r$  is price of the good at retailer's shop.  $t$  is the transportation cost per mile,  $u$  is distance from a consumer to a retailer.

(2) All consumers are supplied with all kinds of goods. The profits of the retailers dealing with the same sort of good are equal. Therefore, the retailers carrying with the same kind of good have the same market in size and shape: The possible market shapes are limited to three shapes, triangle, square, and hexagon. This paper adopts hexagonal market area. Quantity demanded in a market area,  $Q_r$ , is derived by equation (11)<sup>11</sup>:

$$Q_r = 12 \int_0^{\pi/6} \int_0^{U/\cos\theta} (ba - p_r - tu) u du d\theta \quad (11)$$

where  $U$  is the radius of the inscribed circle of market in question.  $\theta$  is an angle formed at the firm's location by two lines, one is the line connecting the firm's location and the mid-point of the side of the market; the other is the line connecting the firm's location and a vertex of the market. The value of  $\theta$  is  $30^\circ$ .

(3) Retailer's cost function is given by equation (12),

$$C = c Q_r + F_r \quad (12)$$

where  $C$  is total cost,  $c$  and  $F_r$  are marginal cost and fixed cost, respectively. Profit of a retailer  $Y_r$ , therefore, is given by equation (13),

$$Y_r = (p_r - c) Q_r - F_r \quad (13)$$

(4) Retailer sets price to maximize its profit. The optimal price is derived from equation (13). Optimal price is given by equation (14),

$$p_r = 0.5(ba + c - (2 \cdot 3^{0.5})0.2027tU) \quad (14)$$

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<sup>11</sup> Derivation method of quantity demanded in the market is shown by Mills-Lav (1964) and improved by Greenhut –Ohta (1973) and others.

## 2) Performance of the central place system formed by the supply principle

If the radius of the largest market is given  $U_L=0.6495a$ , the radiuses of markets of other central places M, S, and H are uniquely settled as  $U_M =0.375a$ ,  $U_S =0.2165a$ , and  $U_H =0.125a$ . By these radiuses the  $b$ 's value in equation (10) is limited into the range from 1.5 to 0.19: Furthermore, the allocation of the  $b$ 's values between central places, L, M, S, and H are determined: Table 1 shows the kinds of goods sold by central places of each level by using  $b$ 's value.

Subsequently, assume that transport cost per mile  $t$  is 1, marginal cost  $c$  is zero. And fixed costs  $Fr$  of retailers in each level are assumed as follows: fixed cost of the retailers which have the largest market is  $0.001a^4$ ; that of retailers whose market are medium and locate at places M is  $0.00005a^4$ ; similarly,  $0.00001a^4$  is assigned to the retailers at S,  $0.000005a^4$  is allocated to the retailers at smallest places H.

Let us derive total quantity demanded  $TQ$  and total profit of all retailers  $TY_r$  in this system. First, sales amounts  $Q_t$  of the goods indicated by the  $b$ 's values of 1.5-1 are derived by equation (15):

$$Q_t = \int_1^{1.5} (12 * 0.6495a^2 ((1/(2 * 3^{0.5}))(ba - 0.5a(b - 0.456) - 0.2027 * 0.6495a))db \quad (15)$$

$Q_t$  is  $0.2900a^3$ . Profits of the retailers are obtained by equation (16) as  $Y_{rt}=0.1184a^4$ .

$$Y_{rt} = \int_1^{1.5} (12 * 0.6495a^2 ((1/(2 * 3^{0.5}))(ba - 0.5a(b - 0.456) - 0.2027 * 0.6495a))0.5a(b - 0.456))db - Fr \quad (16)$$

Secondly, the retailers which locate at both the largest place and medium ones sell the goods whose  $b$  values belong in the range from 1 to 0.58. Sale amounts of these goods are obtained<sup>12</sup>  $Q_t =0.1617a^3$ . And profits of these retailers are calculated as  $Y_{rt} =0.0448a^4$ . Similarly, quantities demanded in smaller markets and profits of the retailers at the lower central places can be obtained. They are shown by  $Q_t$  and  $Y_{rt}$  in Table 1.

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<sup>12</sup> By using the way shown by equation (15), sale amounts of goods which are sold in a market of medium central place are obtained as  $0.0539a^3$ . Since the number of this market in this system is three, sum of quantities purchased is calculated as  $0.1617a^3$ . And then, profits of all retailers dealing with these goods are derived as  $0.0448 a^3$ .

Using these figures in this Table, total quantity of all kinds of goods, TQ and total profit of all retailers, TY<sub>r</sub> are derived as TQ=0.5246a<sup>3</sup>, TY<sub>r</sub>=0.1736a<sup>4</sup>, respectively.

Table 1 Quantity and profit in the central place system of the supply principle

b	1.5-1	1-0.58	0.58—0.33	0.33-0.19
R	L	M	S	H
Q <sub>t</sub>	0.2900a <sup>3</sup>	0.1617 a <sup>3</sup>	0.055 a <sup>3</sup>	0.0176a
Y <sub>rt</sub>	0.1184a <sup>4</sup>	0.0448 a <sup>4</sup>	0.0088 a <sup>4</sup>	0.0016 a <sup>4</sup>

Note:R: Rank of central place, Q<sub>t</sub> : Quantity in markets of each central place,  
Y<sub>rt</sub>: Profits obtained in markets of each central place.

### 3) Performance of the system constructed by the transport principle

The radius of the largest market is also assumed U<sub>L</sub> =0.6495a in the system formed by transportation principle. Then, both location and market of the largest central place are the same as the previous system. While location and market pattern of central places M, S, and H are different from those of the supply principle. The radiuses of their markets become smaller; U<sub>M</sub> =0.3248a, U<sub>S</sub> =0.1624a, and U<sub>H</sub> =0.0812a. Corresponding to the reduced market sizes, in this system the lower bound of b's value is extended to 0.125, and the allocation of b's values between central place levels is not coincided with that of the supply. The b's values allocation is shown in Table 2. Sales amounts and retailer's profits in each level are obtained by the same method used in the above section. They are shown by Q<sub>t</sub> and Y<sub>rt</sub> in Table 2. Total quantity demanded and profit in the system are derived as TQ=0.5377a<sup>3</sup>, TY<sub>r</sub>=0.1794a<sup>4</sup>, respectively.

Table 2 Quantity and profit in the system of the transport principle

b	1.5—1	1—0.5	0.5—0.25	0.25—0.125
R	L	M	S	H
Q <sub>t</sub>	0.2900a <sup>3</sup>	0.1881 a <sup>3</sup>	0.0477 a <sup>3</sup>	0.0119 a <sup>3</sup>
Y <sub>rt</sub>	0.1184a <sup>4</sup>	0.0535 a <sup>4</sup>	0.0066a <sup>4</sup>	0.0008 a <sup>4</sup>

#### 4) Selection of the central place system by a manufacturing firm

Comparison of the quantities demanded and the retailers' profits shown in Table 1 and 2 represents the differences in economic performances achieved by the two systems. Performances in the central place system formed by the transport principle are larger than the system of the supply principle. Based on these economic performances, the system of the transportation principle is superior to the system of the supply one. It should be also noticed, however, that demanded quantities and retailers' profits achieved at the central places of S and H level in the system of the supply principle are greater than those of the transport principle<sup>13</sup>.

Which central place system is preferred by a *manufacturing* firm depends on the its interest. If the firm attaches importance to laborers' welfare, it selects the system of the transport principle because it provides consumers with larger quantity of goods. Furthermore, since this system produces more retailers' profits, tax revenue may be relatively higher, and then public investment in infrastructure is larger, which leads to encourage firm's activity and improve workers' welfare in a region. Therefore, the system of the transport principle attracts the firm's attention. While, if the firm makes much of demanded quantities of goods and profits of the retailers in relatively smaller central places, it selects the system of the supply principle, because small central places in this system achieve greater quantity of goods and the retailers' profits. It is said that the central place systems are important location factor in a firm's selecting an area within the prospective region<sup>14</sup>.

#### IV Four steps in a firm's decision-making of location

Based on the previous analysis, a firm takes four steps to determine its factory's location in large geographical area. Each step is explained as follow.

(1) A firm initially identifies basic elements to affect its factory's location. The information of them is put into the firm's database. On the basis of the obtained information the firm decides the spatial range in which the factory should be located. Chaotic phenomenon may have an opportunity to be used to the definition of a prospective region in large space.

(2) Within this region the firm selects a potential area. Since the central place system that lays in the area influences not only the firm's profits but workers' welfare, the

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<sup>13</sup> In order to evaluate the robustness of these results we have to carry formal statistical hypothesis testing.

<sup>14</sup> In this paper, the central place system is evaluated from the retail side. The system should be investigated from the production side.

system can play a significant role in the selecting area: It can be said that selection of an area means a choice of a central place system.

(3) An urban district in the system is chosen by the firm. Since individual urban districts have different economic characteristics to attract a factory, each district has the possibility to attract a factory: For example, the largest city provides various kinds of economic functions and is equipped with large scale infrastructures. Thus, this city may be chosen by the factories that need various external agents with respect to finance, market information and recruitment and so on. While, if a factory requires a large plot to produce goods, it may select a small city.

(4) Finally, the firm decides a site within the urban district. The firm estimates various practical factors about potential sites in question such as the price of land, surrounding environment, and the difficulty of negotiation with landlords.

These steps should be taken by every manufacturing firm when it researches a site for a factory within large space<sup>15</sup>.

#### V Conclusion remarks

Location of factories affects various economic activities of a firm in different ways: It influences the production mode, the logistics of intermediate goods and final ones, and the price of goods and so on. Location issue has been one of the important tasks for manufacturers. Nowadays, there are two factors which characterize the firm's location choices: First, referring the technology adopted in the production of factory, manufacturer searches the most preferable site within vast geographical area: Secondly, many hi-skilled workers reside at the place that possesses comfortable circumstances to live. Without consideration of these facts current firms would not successfully manage its factories.

Corresponding to the above view, this paper proposed that a firm should take a series of steps to determine a factory's location site; (1) determination of a prospective region, (2) selection of a potential area within the region, (3) choice of an urban district within the area, (4) decision of a site in the district. In the first step, chaotic phenomenon may have the possibility to be used to define a prospective range. In the second step, a firm should consider the central place system as a factor to select an area. Because the central place system directly influences workers' lives and indirectly affects firm's profit, this system plays a significant role in a firm's area selections.

Fragmentation of production processes proceeds on a world wide scale, and

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<sup>15</sup> Nishioka-Krumme (1973) also shows that firms take three steps to determine the location; the selection of the market, the decision of possible area and the site.

fragmented production blocs are now able to scatter across the borders of countries. At the same time, there are many regions which need to attract factories to vitalize their economies. Considering the results derived from the above analysis, it may be said that the governments of regions are required to not only care individual cities, but also to restructure the existing urban system. The urban system should be considered as an important location factor which attracts firms' location and develop regional economy.

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