# Influence of Location Factors Activated by Economic Policy on Industrial Park

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## 1. Introduction

The globalized economy has brought about major changes in activities of the manufacturing firms and in contents of the government’s economic policies. The essential mechanism of these changes can be summarized as follows. The progress of the globalization economy intensifies international price competition among the manufacturing firms. Because prices of manufactured products depend heavily on production costs, the price competition raises cost cutting competition. To reduce the production costs, the manufacturing firms fragment production processes and they distribute the fragmented processes to developing countries and regions where labor costs are much lower. The fragmented production processes of the firms are connected by physical distribution and information networks. Firms’ activities are organized internationally. On the other hand, when the production processes are fragmented and moved easily to the foreign countries, many countries plan to induce the processes to their own countries and contribute to their economic development. To realize this plan, the countries enhance their infrastructure with various economic policies.

The fragmented production processes are relatively small, and their production content becomes simplified. Thus, the firms can easily move some production processes to the foreign countries, and the countries need only to construct a small infrastructure to attract those production processes to their own territories. In this context, it can be considered that industrial park is used as a useful means to attract the production processes. The establishment of industrial parks has been evaluated by many economist as a powerful economic strategy.[1)]

1） The policies of industrial parks have various purposes, including the formation of simple

Industrial park does not include production processes of all business types: Since each industrial park has its own individuality, the business types of the tenants of each park vary according to the characteristics of each park. When government establishes an industrial park, it carefully plans the production mode and location of the industrial park taking into consideration the regional industrial economic structure and the economic development stage in the region. This paper analyzes the location and production structure of industrial park from the viewpoint of industrial location theory.

The organization of this paper is as follows. The section 2, from the viewpoint of traditional location theory, describes how transportation cost and agglomeration economies affect factory's location, and it shows how industrial park is suitable to attract the factories and is useful to as a means of economic policy of regional and national government. Section 3 builds a model for a firm's location determination. Using this model, it is examined how location of the industrial park is determined. In addition, this model is used to show a reason why regional government can have an opportunity to intervene the park's location considering the regional economic conditions. And, this section analyzes the locational power of the factors activated by national government' policy on industrial park; it is shown that the corporation tax rates and the freight rates have a power to change the industrial park's location. Section 4 assumes the situation that government as a developer of industrial park establishes two industrial parks in different sites to directly attract the factories into the certain sites. And it analyzes how many factories are attracted to each industrial park. And then, the section examines the effects of agglomeration economies on the firms' production costs and profits. Section 5 summarizes the findings of the analysis in this paper.

## 2. The effect of industrial park on factory's location

According to A. Weber (1909), this section examines how the general location factors affect factories' location. From the perspective of the industrial location theory, the examination clarifies how industrial park hauls the factories.

### 2.1. The function and classification of traditional location factors

The factors that affect location of a factory are named as location factor. Location factors are categorized from two perspectives. The first perspective focuses on the object on which the location factor affects. The factors that affect the location of all factories are classified into the group of the general location factor, whereas the factors influence only on specific factories are classified as the special location factor.

As the former general location factor, transportation costs, labor costs, and

production sites and the economic foundation of cities (see Bredo, 1960).

agglomeration economies are listed up. On the other hand, as the latter special location factor, many factors can be considered, humidity is a typical special location factor.

The second perspective is based on how location factors act. From this viewpoint factors are classified into a directional location factor and an agglomeration factor. The former means that the factors acting to lead a factory to a specific point, for example, exemption of property taxes and the provision of subsidies granted to the factories by a regional government. The latter agglomeration factor is factor that acts in a way that brings factories to a place, rather than hauling them to a specific site.

### 2.2. Usefulness of industrial park in regional economic development

Regional government may design the following factory inducement policy based on classification of location factors as described above: A regional government announces the reduction and exemption of the fixed asset tax which are a directional location factor. Receiving this information, multiple firms set up their factories in the area to reduce the fixed asset tax. As a result, agglomeration is formed in the area, and it generates agglomeration economies without any intention. Because the area gains general location factor of the agglomeration economies, firms do not ignore this area when considering factory's location.

The location plan as described above utilizes a method that accidentally produces agglomeration economy. Establishing an industrial park is the method to anticipate the work of agglomeration economy and to intentionally attract factories into a specific place. Industrial park is a kind of means to form in advance the basic infrastructure such as logistics, information, financial functions and attract factories from outside area. For this reason, industrial parks have become one of the most important policy measures in many national and regional economic development policy.[2]

## 3. Analysis of effects of factors activated by economic policy on industrial park

This section, first, constructs a theoretical model for determining the location of industrial park and theoretically examines how the location and production composition of industrial park are determined.

### 3.1. Basic assumptions in the analysis

Basic assumptions and analysis framework are introduced as follow.[3] A firm produces

2) Various kinds of industrial parks in many developing countries are described by Pose-Hardy (2014).

3) The analysis framework used here is constructed according to Puu (1998) and Ishikawa (2016).

final products by two production processes, the first process and the second one. The first production process is assigned to the factory 1 which is in the home country. The factory 1 manufactures intermediate goods, mq. The second production process is assigned to the factory 2 which locates in the foreign country. The factory 2 composes the final products from the intermediate goods.

The intermediate goods are transported from the factory 1to the factory 2 by using the transfer price, mp.[4)] The factory 2 uses one unit of the intermediate goods to produce one unit of the final goods. The factory 2 sells the finished goods to the marketplace in the foreign country. There is no tariff in the movement of the intermediate goods from the factory 1 to the factory 2. The factory 2 is in the position of the monopoly in the market. The factory 2 determines the supply amount of the final goods at the market in order to maximize *the factory 2's* profit. On the other hand, the factory 1 decides the transfer price of the intermediate goods to maximize the *firm's* profits. The corporation tax rates of the home and the foreign country are represented by t and $t^*$, respectively.

### 3.2. Derivation of the profit function of the factory 1

The profit of the factory 1, $Y_1$, is shown by equation (1),

$$Y_1 = (1-t)\,[mp^{*}mq - C(mq) - F_1] \tag{1}$$

where C (mq) is variable cost function and $F_1$ is fixed cost of the factory 1. The cost function C (mq) is derived on the following assumptions. The factory 1 uses two kinds of materials $m_1$, $m_2$ to produce the intermediate goods. In addition, the factory 1 needs a lubricating oil $m_3$ to operate its machines. The materials $m_1$, $m_2$ and the oil $m_3$ are produced at points $M_1$, $M_2$ and $M_3$ which are identified by coordinates $(x_1, y_1)$, $(x_2, y_2)$, and $(x_3, y_3)$, respectively. These materials are transported to the factory 1 located at point L which is indicated by (x, y). The factory 2 locates at the market at point $M_4$, $(x_4, y_4)$. Freight rates of the materials $m_1$, $m_2$ are denoted by $t_m$, and the rate of the oil $m_3$ is denoted by $t_e$. The freight rate of the intermediate goods is $t_g$. Mill prices of these materials and oil are assumed to be given for the simplicity, and these prices are shown by $p_1$, $p_2$, and $p_3$. Figure 1 illustrates the geographical relationships between the factory 1, the factory 2, the market and three points where the materials are produced. The home country is shown by the square area and that of the foreign country is shown by the upper rectangle area. The final goods market is indicated by the black square mark at point $M_4$. The border between the two countries is shown by the horizontal bold line in Figure 1.

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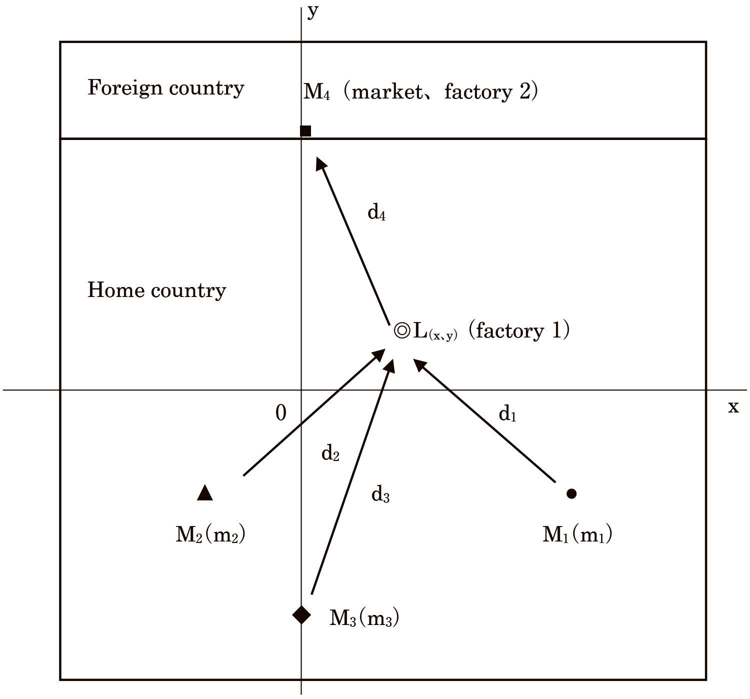
The first systematic analysis of agglomeration is A. Weber (1909), which provides a lot of useful knowledge. The mechanism in which firms' production system is organized internationally is successfully explained by Shi-Yang (1995).

4 ) The transfer price is explained by Hirshleifer (1956).

**Figure 1** Location Figure




The production function of the intermediate goods, mq is supposed as equation (2),

$$mq = Am_1^{\alpha} m_2^{\beta} \quad (2)$$

where A indicates the production efficiency of the factory 1, $\alpha$ and $\beta$ are parameters and they are defined as $A > 0$, $0 < (\alpha + \beta) < 1$. And the distances between the material places, $M_i$ ($i = 1, 2, 3$) and location, L (x, y), of the factory1 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 two factories is given by $d_4$,

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

The delivered prices Pi ($i = 1, 2, 3$) of the two materials and the lubricating oil at the location site of the factory 1 are shown by equations (4a, b, c), respectively:

$$P_1 = p_1 + t_m d_1 \quad (4a)$$
$$P_2 = p_2 + t_m d_2 \quad (4b)$$

$$P_3 = p_3 + t_e d_3. \tag{4c}$$

And the transportation cost of the intermediate goods is borne by the factory 1. Thus, the price of the intermediate goods, DP, which is needed to calculate the revenue of *the factory 1* is represented by equation (5),

$$DP = mp - t_g d_4. \tag{5}$$

Making use of the law of equi-marginal productivity, that is, the ratio between the productivities of the two raw materials should be equal to the ratio between their delivered prices, quantities of them are derived as equations (6a) and (6b): (For simplicity, $\alpha$ and $\beta$ are assumed $\alpha = \beta = 0.4$):

$$m_1 = A^{-1.25} mq^{1.25} ((p_2 + t_m d_2)/(p_1 + t_m d_1))^{0.5} \tag{6a}$$
$$m_2 = A^{-1.25} mq^{1.25} ((p_1 + t_m d_1)/(p_2 + t_m d_2))^{0.5}. \tag{6b}$$

The quantity of the oil $m_3$ is given by a linear function of amount of the final goods as equation (6c),

$$m_3 = mq. \tag{6c}$$

From these equations, the cost function C (mq) is obtained as equation (7),

$$C(mq) = 2A^{-1.25} mq^{1.25} (p_1 + t_m d_1)^{0.5} (p_2 + t_m d_{2)}{}^{0.5} + mq(p_3 + t_e d_3) + F_1. \tag{7}$$

The profit function of the factory 1 is rewritten as equation (8),

$$Y_1 = (1-t)[mq((mp - t_g d_4) - (p_3 + t_e d_3)) - 2mq^{1.25} A^{-1.25} (p_1 + t_m d_1)^{0.5} (p_2 + t_m d_{2)}{}^{0.5} - F_1]. \tag{8}$$

### 3.3. Profit functions of the factory 2 and the manufacturing firm

Let us derive profit of the factory 2. The profit is derived under the following assumptions: The market demand function is represented by equation (9),

$$p = a - vQ \tag{9}$$

where p is the market price of the final goods, $a$ is the maximum reservation price and $v$ is a parameter. For simplicity $a$ and $v$ are assumed 600 and 1, respectively. If the cost of composing the intermediate goods to the finished goods is represented by C (Q) and the fixed cost of the factory 2 is represented by $F_2$, the profit of the factory 2, $Y_2$, is represented by equation (10),

$$Y_2 = (1-t^*)[pQ - mp^* mq - C(Q) - F_2]. \tag{10}$$

Suppose that the composing cost C (Q) is given by equation (11),

$$C(Q) = \gamma Q(\delta + Q)^2/\varepsilon \tag{11}$$

where parameters $\gamma$, $\delta$, $\varepsilon$ are assumed as1.5, 2, 200 for the simplicity of the calculation, respectively. Since the factory 2 uses one unit of the intermediate goods to produce one final goods, *mq* can be replaced by Q. The profit function is rewritten by equation (12),

$$Y_2 = (1 - t^*)[(p - mp)Q - 1.5Q(2 + Q)^2/200 - F_2] \tag{12}$$

Since the market price of the final good, p, is a function of the quantity Q as shown by equation (9), the optimal quantity supplied at the market to maximize the profit of the factory 2 can be derived by using equation (12). The optimal supply quantity is given by equation (13),

$$Q = 0.22(-206 + (582409 - 900mp)^{0.5}). \tag{13}$$

As the supply quantity Q is a function of the transfer price, mp, the profit of the factory 2 is represented as a function of the transfer price as equation (14),

$$Y_2 = (1 - t^*)[(600 - (0.22(-206 + (582409 - 900mp)^{0.5})) - mp)(0.22(-206 + (582409 - 900mp)^{0.5})) - F_2]. \tag{14}$$

By summing up the profits of the factory 1 and 2, the firm's profits, Y, can be obtained as equation (15). The firm's profit is a function of the transfer price, *mp*, and the location, (x, y), of the factory 1.

$$\begin{aligned} Y = {} & (1 - t)[(0.22(-206 + (582409 - 900mp)^{0.5}))((mp - t_g d_4) - (p_3 + t_e d_3)) \\ & - 2(0.22(-206 + (582409 - 900mp)^{0.5}))^{1.25} A^{-1.25} (p_1 + t_m d_1)^{0.5} (p_2 + t_m d_{2)})^{0.5} - F_1] \\ & + (1 - t^*)[(600 - (0.22(-206 + (582409 - 900mp)^{0.5})) - mp)(0.22(-206 \\ & + (582409 - 900mp)^{0.5})) - F_2]. \end{aligned} \tag{15}$$

### 3.4. Derivation of Location Prospective Area

3.4.1. Appearance of chaotic phenomenon

Let us derive the optimal location (X, Y) of the factory1 and the transfer price of the intermediate goods by using equation (15). To derive the location of the factory 1 and the transfer price, the gradient dynamics is used (Puu, 1998, Ishikawa, 2009). The essence of the gradient dynamics is that first, an initial value set is given to $x_n$, $y_n$, and $mp_n$ in the following equations (16a, b, c) as a temporal solution, and obtain second tentative values of $x_{n+1}$, $y_{n+1}$, and $mp_{n+1}$ by calculations indicated by the three equations (16a, b, c). The same calculation is carried out literately until a given tentative solution can be approximately judged as the solution: If the values of $(x_{n+1,} y_{n+1,} mp_{n+1})$ in equations (16a, b, c) become approximately the same as those of $(x_{n,} y_{n,} mp_n)$, the values are admitted as the solution.

$$x_{n+1} = x_n + j^* \partial Y/\partial x, \qquad (16a)$$
$$y_{n+1} = y_n + j^* \partial Y/\partial y, \qquad (16b)$$
$$mp_{n+1} = mp_n + j^* \partial Y/\partial mp, \qquad (16c)$$

where j is the width of a step and *n* shows the number of the calculation. And $\partial Y/\partial x$, $\partial Y/\partial y$, and $\partial Y/\partial mp$ are given by the following equations (17a, b, c), where the production efficiency A is assumed as 1 and the corporation tax rates of the two countries are assumed as $t = t^* = 0.82$.

$$\partial Y/\partial x = 0.18[-tgx(299.4-0.5mp)/d_4 + (299.4-0.5mp)(-t_g(x/d_4) - t_e(x/d_3)) - 1^{-1.25}(299.4-0.5mp)^{1.25} t_m[\{(p_2+t_m d_2)^{0.5}/(p_1+t_m d_1)^{0.5}\}(x-x_1)/d_1 + \{(p_1+t_m d_1)^{0.5}/(p_2+t_m d_2)^{0.5}\}(x+x_2)/d_2]] = 0 \qquad (17a)$$

$$\partial Y/\partial y = 0.18[-tg(y-1)(299.4-0.5mp)/d_4 + (299.4-0.5mp)(-t_g((y-y_4)/d_4) - t_e((y-y_3)/d_3) - 1^{-1.25}(299.4-0.5mp)^{1.25} t_m[\{(p_2+t_m d_2)^{0.5}/(p_1+t_m d_1)^{0.5}\}(y+y_1)/d_1 + \{(p_1+t_m d_1)^{0.5}/(p_2+t_m d_2)^{0.5}\}(y+y_2)/d_2]] = 0 \qquad (17b)$$

$$\partial Y/\partial mp = 0.18[-(0.5^*mp-299.4) + 0.22(299.4-2^*0.5mp+0.5t_g d_4 + 0.5(p_3+t_e d_3)) + + 2.5^* 1^{-1.25}(p_2+t_m d_2)^{0.5}(p_1+t_m d_1)^{0.5}(299.4-0.5mp)^{0.25}] = 0. \qquad (17c)$$

Let us derive the optimal location of the factory 1 and the transfer price by assigning numerical values to parameters as follows: ($x_1 = 3$, $y_1 = -0.5$), ($x_2 = -3^{0.5}$, $y_2 = -0.5$), ($x_3 = 0$, $y_3 = -1.5$), ($x_4 = 0$, $y_4 = 1$), $p_1 = 0.25$, $p_2 = 2$, $p_3 = 0.2$, $t_m = 0.11$, $t_e = 0.01$, $t_g = 0.225$, $F_1 = 5000$, $F_2 = 2500$. The calculation results derived from the gradient dynamics are shown by Figure 2A. Figure 2A reveals that the transfer price of the intermediate goods is approximately 442 and the optimal location is hidden by a chaotic phenomenon.[5)] Although the accurate location of the factory 1 is not identified by the appearance of the chaotic phenomenon, the chaotic phenomenon provides an important information that the optimal location is within the area where a chaotic phenomenon appears because it appears around the optimal solution. If firm locates the factory 1 within the chaotic area, it's profit is almost same. When the firm locates the factory 1 at point $M_1$, the profits is derived as 3482. The firm obtains the almost same profits when the factory1 locates within the area where the chaotic phenomenon appears.

If location of the factory 1 is settled at point $M_1$, profits of the firm and the factory 1 , its' production amount are derived; they are shown at the upper row in Table 1. And if the

5) The phenomenon shown in Figure 2 is a *chaos* or a *chaotic* phenomenon which is generated from the Cauchy convergence in the solution derivation process. The study to identify this phenomenon is not conducted in this paper because this problem does not make any obstacle to logical development. This interest issue is going to be discussed elsewhere.

freight rates of the intermediate goods becomes higher as 0.85, as shown by Figure 2B, the chaotic area appears around the market place. In this case the factory1 locates near point $M_4$. And the location of the factory 1 is settled next to the market place, point $M_4$, the profit of the factory 1, the transfer price, and the firm's profit are derived. They are indicated in the middle row in Table 1.

Finally, when the freight rate is 0.7728, the chaotic area appears becomes very long, it covers from $M_1$ to $M_4$ as shown Figure 2C. In this case the factory1 can locate between these two points, and the profit of the factory 1, the transfer price, and the firm's profit are derived as indicated by the lowest row in Table 1.

**Figure 2A** Position of chaotic area in low freight rate

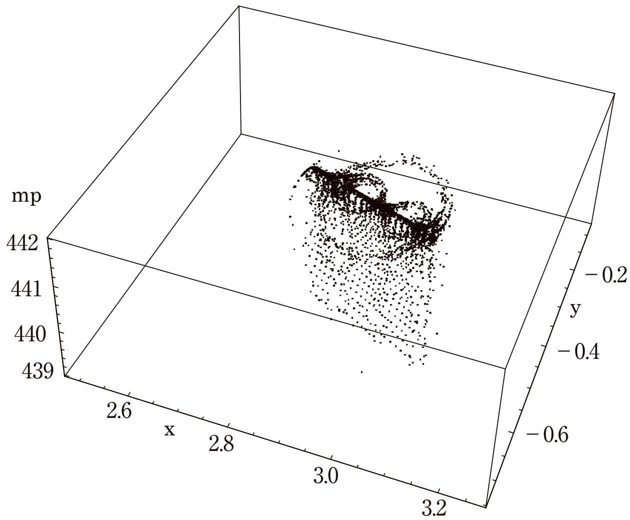



**Figure 2B** Position of chaotic area in high freight rate

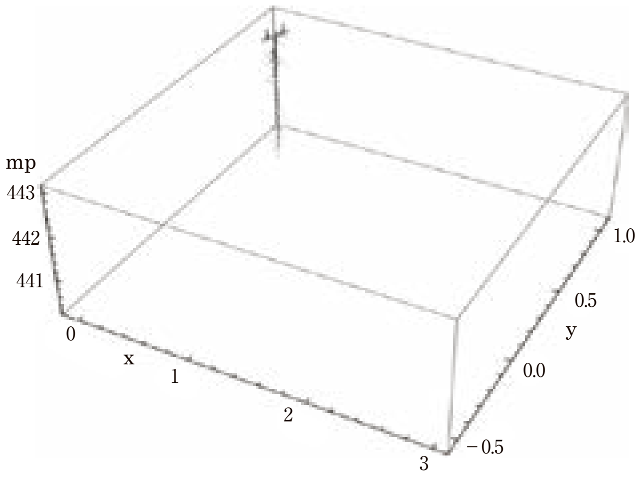


**Figure 2C** Position of chaotic area in moderate freight rate

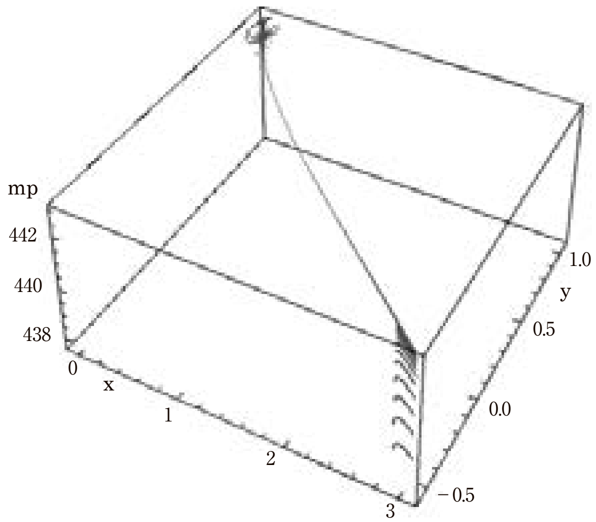



**Table 1** Location, transfer price and profit of factory in different freight rates

| freight rate | location | transfer price | profit of firm | profit of factory |
|---|---|---|---|---|
| $t_g = 0.225$ | around $M_1$ | 442 | 3482 | 2968 |
| $t_g = 0.85$ | around $M_4$ | 443 | 3450 | 2948 |
| $t_g = 0.7228$ | $M_1$～$M_4$ | 442.4～443 | 3455.8～3450.4 | 2947.9～2948.1 |

3.4.2. Locational implication of chaotic area

The chaotic phenomenon has an interesting locational implication as follow: As long as the firm selects the location of the factory 1 and transfer price of the intermediate goods within the sphere of the chaotic phenomenon, the firm can obtain the almost same highest profits. It could be, therefore, considered that the spatial range of the phenomenon indicates *Location Prospective Area* (it is referred as LPA for short) for a possible factory's location. By setting a Location Prospective Area in large geographical space by using the chaotic phenomenon the firm can squeeze the searching area into a small range; they can significantly reduce the searching costs. Chaotic phenomenon may provide a firm with useful information about its location selection. And the firm can select the location considering various factors such as education, dwellings, medical, and security within the LPA.

### 3.5. Determination of location and production composition of industrial park

3.5.1. The basic idea of determination method of location and composition of industrial park

An industrial park is composed of several factories belonging to plural industries. In this section, the location of industrial park and its composition are analyzed assuming only three factories belonging to three business types. Each type is represented by *a, b, c*. Then, location of each factory $1_a$, $1_b$, $1_c$ is derived under the same location Figure as illustrated in Figure 1. However, the parameter A of the production function of the intermediate goods produced by the factory $1_c$ is changed to 1.05, and the freight rate $t_{gc}$ is assumed as 0.825. they are shown in Table 2.

On these assumptions, LPAs of the three kinds of factories, $1_{a,}$ $1_b$ and $1_c$ are shown by Figure 3A and 3B. LPA of the factory $1_b$ is long, it covers long area from point $M_1$ to point $M_4$, and LPA of the factory $1_a$ is generated around point $M_1$and that of the factory $1_c$ is generated around point $M_4$.

Table 3 indicates the profit, intermediate goods' price and production amount of each factory. Although the factory *1b*'s production amount and the price of the intermediate good are different according to its location, the firm *b's* profit becomes almost same regardless the factory's location. Thus, Firm *b* has many alternatives in the selection of the factory's location. The central part of Table 3 shows the firm *b's* economic conditions in the only two cases when it locates at point $M_1$ and $M_4$.

**Table 2** Parameter values for the three kinds of firms

| parameter | factory $1_a$ | factory $1_b$ | factory $1_c$ |
|---|---|---|---|
| A | 1 | 1 | 1.05 |
| $t_g$ | 0.225 | 0.7728 | 0.825 |

**Figure 3A** Overlapping area around point $M_1$

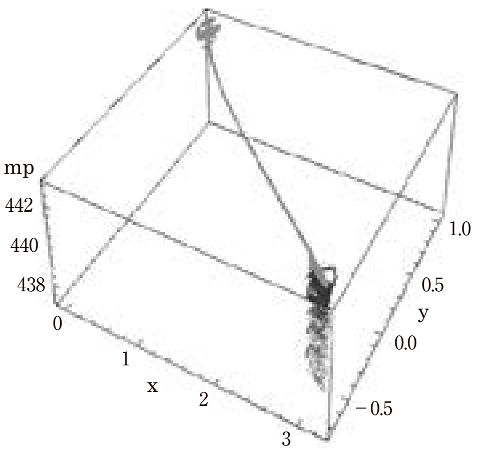



**Figure 3B** Overlapping area around point $M_4$

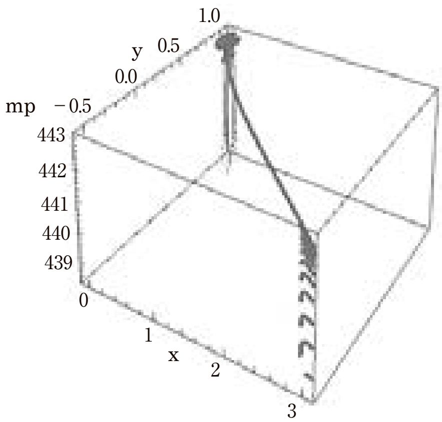


**Table 3** Location of factory and firm's profit

| | factory $1_a$ | factory $1_b$ | factory $1_b$ | factory $1_c$ |
|---|---|---|---|---|
| L | $M_1$ | $M_1$ | $M_4$ | $M_4$ |
| mp | 442 | 442.5 | 443 | 442.5 |
| mq | 49.19 | 49.09 | 48.97 | 49.09 |
| $Y_{1i}$ | 2971 | 2948 | 2948 | 2952 |
| $Y_{2i}$ | 516 | 508 | 502 | 508 |
| $Y_i$ | 3487 | 3456 | 3450 | 3460 |

When a developer of an industrial park attracts factories as tenants, it is naturally assumed that the factories which have the same locational trend are likely to be attracted to industrial park. Based on this assumption, the overlapping area of the LPAs is considered as area where industrial park is likely to be established. In the case shown by Figure 3A and 3B, two overlapping areas are generated in around point $M_1$ and $M_4$ in the location Figure. Thus, it could be said from the position of the overlapping areas of LPAs that industrial park established at point $M_1$ is composed by the factories, $1_{a,}$ $1_b$, while, industrial park established near point $M_4$ is composed by the factories,$1_b$, $1_c$: And the location of industrial park is not limited into a place, but the park is allowed to locate at any sites within the overlapping area.

3.5.2. The growing importance of regional economic policy in area

From the perspective of firms' profits, location of the industrial park is not limited to a specific point, but it is allowed to locate at any point within the overlapping area by LPAs. This fact is to give great usefulness to the regional government's location policy.

Industrial park brings corporation tax revenue to the regional government and provides employment opportunities in the area. Industrial park gives the opportunities for the local economy to be revitalized and it may improve social community life such as education, housing, and medical care and so on. Regional government can manipulate the location of industrial parks that can play such a role almost freely within overlapping area of LPAs. The regional government investigate the socio-economic contents in the area from various respects, and then, based on the result from the investigation the government can decide the location of industrial park at the place where the industrial park is most effective. Regional economic development policies can demonstrate their significance through industrial parks in the area.

3.5.3. Locational effects of national government's location policy on industrial park

Normally, the economic policy of the government is larger than that of the regional government. Consequently, the government's location policy also has a large impact on the location of factories and industrial parks through corporation tax rates, freight rates, and tariffs and so on . This subsection takes up the corporation tax rate and investment on transportation. And it analyzes the effects on industrial park of the decrease of corporation tax rates and of the reduction of the freight rates by the investment on the traffic system.

3.5.3.1. The effects of decrease of corporation tax rates on industrial park

Assume that the factories of three business types are under the same location Figure shown Figure 1. And this subsection considers that where LPAs of factories *1*a, 1*b* and *1c* appear if the corporation tax rates of home and abroad reduce from 0.82 to 0.52. Figure 4 shows the LPA of each factory.

In this case, although the positions of the LPAs of the factory $1_a$ and the factory $1_c$ maintain around point $M_1$, the LPA of factory$1_b$ is squeezed toward point $M_4$. Overlapping area by the two LPAs of the factory $1_b$ and factory $1_a$ is disappeared. And as shown by Figure 4, an overlapping area by the LPAs of factory $1_b$ and factory $1_c$ is formed only at point $M_4$. It is said from this analysis that the reduction of the corporation tax rate establishes industrial park by firm$1_c$ and firm$1_b$ near point $M_4$: The economic policy to reduce corporation tax rate exercises locational power to move the positions of LPAs of factories and it affects the determination of location and production composition of industrial park.

3.5.3.2. The effects of investment on the transportation on industrial park

Among the government's economic policies, there is an economic policy that reduces transportation costs by actively investing in transportation and influences on factory location. In this subsection, it is assumed that the freight rates of intermediate goods manufactured by the factories $1_b$ and $1_c$ *are reduced* by the government's investment in transport system as shown in Table 4.

In this case, the LPAs of all factories are generated around point $M_1$. Overlapping area

**Figure 4** Formation of industrial park at point $M_4$

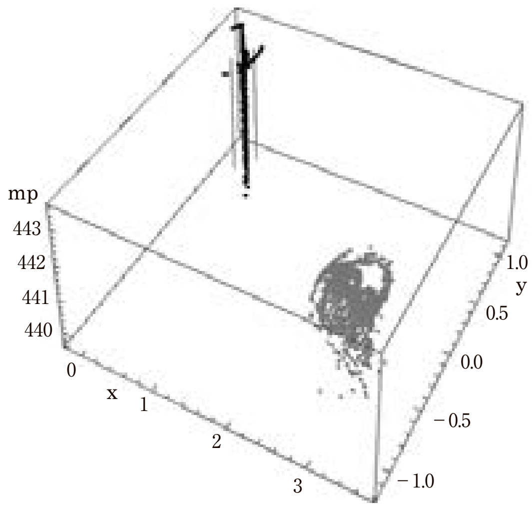
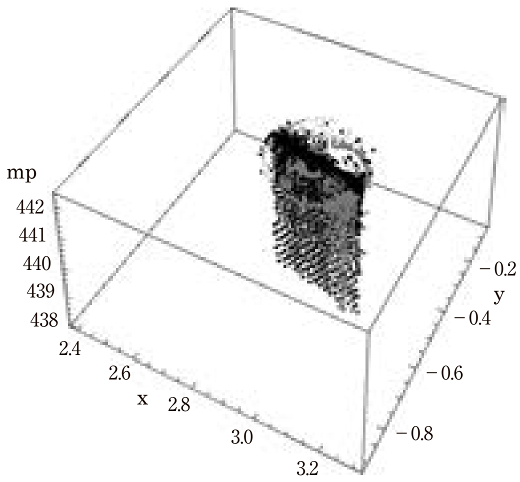


**Table 4** Parameter values for the three kinds of factories

| parameter | factory $1_a$ | factory $1_b$ | factory $1_c$ |
|---|---|---|---|
| $t_g$ | 0.225 | 0.45 | 0.225 |

**Figure 5** Formation of industrial park composed by three factories at point $M_1$




by the three LPAs is formed around point $M_1$. It is said from the Figure 5 that the reduction of the freight rates generates large industrial park at point $M_1$ which produces the material $m_1$: The economic policy to investment on traffic system to reduce the freight rates exercises locational power to move the positions of LPAs of factories and it affects the determination of location and production composition of industrial park.

It should be notified that economic policy by the national government can affect them not only indirectly but also directly on the location of factories and industrial parks.

## 4. Effect on factory location of construction of industrial park

The above sections analyzes locational effects of corporation tax rate and freight rates. It is shown in the analysis that the decrease in the corporation tax rate by the government's policy moves the footloose-type factory *1b* to the vicinity of the market, and the industrial park is consisted by the factory *1c* and factory *1b*. And the freight rates reduction due to the road improvement by the government moves factories *1c* and *1b* to the raw material site $M_1$. As a result, the industrial park near the raw material site $M_1$ is consisted by the factories *1a*, *1b*, *1c*. This analysis suggests that the government's policies can indirectly promote the coexistence of factories and also determine composition of business types in each industrial park.

In addition to these policies, the government has another policy measure that affects the location of factories and directly promotes the coexistence of factories. The policy is for the government to become a developer of industrial park and agglomerate factories. This is a means of agglomerating factories through agglomeration economies. In the traditional industrial location theory, it is considered that the agglomeration economies occur and gradually increase as the agglomeration of factories progresses. However, by establishing industrial park, the government can prepare and provide the agglomeration economies before factories are agglomerated. This means allows the government to draw and agglomerate the factories to their intended sites.

It is difficult to use the same framework in the previous sections to analyze industrial parks which take advantage of the agglomeration economies to attract the factories. Thus, this section reconstructs framework to analyze effects of establishing industrial park utilizing results derived in the previous sections in the analysis of the industrial parks.

### 4.1. Selection of industrial park by firms

4.1.1. Framework and assumptions of firm's industrial park selection

The developer of industrial parks presents the location points of industrial parks and announces the contents of infrastructure provided by the industrial parks to the firms planning a factory construction. The firms compare the parks' locations and contents and decide an industrial park to locate new factory. Here, assuming the same situation as in the previous section and using the provided results in that section , it can be considered as follows. The promising location for the industrial park is the place around the point $M_4$, which is a market site, and the place around the point $M_1$, which is the raw material site. Thus, this subsection assumes that the developer constructs two industrial parks at the above two places: One is the industrial park MF in the raw material site $M_1$. The other is the industrial park MO in the market site $M_4$. This subsection analyzes how the firms belonging to the business category *b* select an industrial park out of the two industrial parks.[6)]

The characteristics of each industrial park are assumed as follows: The factories near the raw material site are in charge of raw material processing with a large device and machinery, and scale of the factories is large. Thus, the industrial park MF is constructed to provide relatively favorable production conditions to the factories that require a relatively large production infrastructure. On the other hand, the factories near the market site are in charge of the final process in the product manufacturing and have a relatively labor-intensive character. It is assumed, thus, that the industrial park MO has characteristics suitable for the factories that require a relatively wide variety of labor.

6） It is assumed here that there are multiple firms belonging to the business type b. And the factory *1a* and the factory *1c* are temporarily ignored in this analysis.

Assuming that the number of firms belonging to the business type *b* is four, this subsection analyzes how these four firms make the choice between these two industrial parks.

4.1.2. Selection of industrial park by firms

Analysis on the selection of industrial parks by the four firms belonging to business type *b* is conducted based on the dynamic model proposed by Deneubourg-Palrna-Kahn (1979) which has been expanded and sophisticated by Matsumoto-Asada (1999).

The number of the firms with type *b* that select the industrial park MF is notified as NF, and the number of the firms that select the industrial park MO is notified as NO. The numbers of NF and NO fluctuate according to the dynamic equation (18i, ii) in which $\dot{NF}$ and $\dot{NO}$ indicate the fluctuation, respectively,

$$\dot{NF} = (Nb^{*}VF/(VF+VO)) - NF \tag{18i}$$
$$\dot{NO} = (Nb^{*}VO/(VF+VO)) - NO, \tag{18ii}$$

where *Nb* is the number of the firms with type b, and it is assumed to be *four* as described above. VF and VO represent the attractiveness of the industrial parks, MF and MO. The attractiveness is generated from the characteristics of each industrial park and the attractiveness is indicated by (19i, ii) respectively,

$$VF = RF^{*}NF^{\mu} \tag{19i}$$
$$VO = RO^{*}NO^{\rho}, \tag{19ii}$$

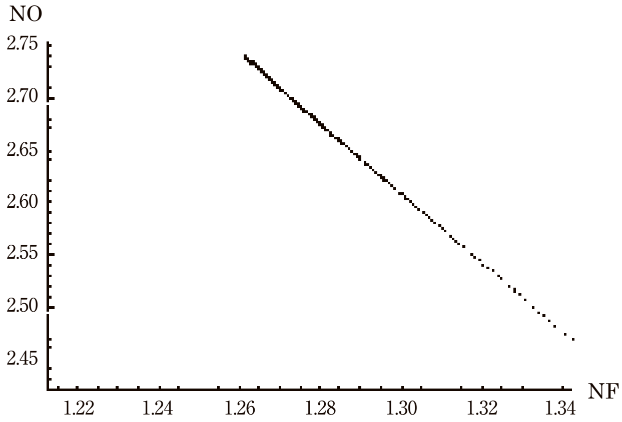
where RF and RO show the characteristic factor that is the source of the attractiveness of the industrial parks MF and MO, and RF $>$ 0, RO $>$ 0, $\mu$ and $\rho$ are parameters, and $-1 < \mu < 0$ and $0 < \rho < 1$. Therefore, the above equation (19i, ii) indicates the characteristics of the industrial park as described above. Industrial park MF tends to be advantageous for the larger scale factories. For this reason, the increase in the number of factories causes a kind of congestion in the industrial park and impairs its attractiveness. On the other hand, the industrial park MO is relatively advantageous for the factories that use small machines to manufacture products in the final process and also take charge of office functions. Therefore, the increase in the number of the factories increases the attractiveness of the industrial park MO.

From the above equations (18i, ii) and (19i, ii), the dynamic equations showing the variation of NF and NO are re-expressed by the following equations (20i, ii),

$$\dot{NF} = Nb^{*}RF^{*}NF^{\mu}/(RF^{*}NF^{\mu} + RO^{*}NO^{\rho}) - NF \tag{20i}$$
$$\dot{NO} = Nb^{*}RO^{*}NO^{\rho}/(RF^{*}NF^{\mu} + RO^{*}NO^{\rho}) - NO. \tag{20ii}$$

If the dynamic equations are derived as in equations (20i, ii), selection of the industrial parks by the firms with type *b* can be obtained as follows. Solving the next two equations

**Figure 6** Selection of industrial park between MF and MO by the four firms with type b




(21i, ii) with respect to NF and NO by the gradient dynamics gives the equilibrium solution (NF*, NO *). This equilibrium solution indicates the selection of industrial park between MF and MO by the four firms. It is assumed here that the numerical values of the parameters are $\mu = -0.95$, $\rho = 0.55$, RO = 2, RF = 2, and Nb is 4.

$$\dot{NF} + j^* (4^*2^*NF^{-0.95})/(2^*NF^{-0.95} + 2^*NO^{0.55}) - NF \quad (21i)$$
$$\dot{NO} + j^* (4^*2^*NO^{0.55})/(2^*NF^{-0.95} + 2^*NO^{0.55}) - NO \quad (21ii)$$

where j is the adjustment speed, and j = 1.93.

Figure 6 shows the equilibrium solution (NF *, MO *) of NF and NO, which indicates the selection of industrial park between MF and MO by the four firms.[7] As shown in Figure 6, each point which indicates a temporary solution moves toward the equilibrium solution and converges to the point (1.26, 2.74). It is shown that the numbers of the firms with type *b* in the industrial park MF and MO are 1.26 and 2.74, respectively.

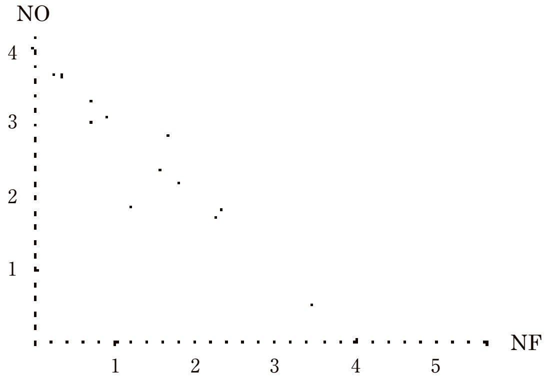
4.1.3. Occurrence of chaotic phenomenon in firms' industrial park selections

As elaborately analyzed and shown by Matsumoto-Asada (1999), chaotic phenomena may occur in the process of deriving the above equilibrium solution by using this method. This subsection briefly examines a chaotic phenomenon in this situation: Let us inquire how the four firms with type *b* select the industrial parks MF and MO by setting the adjustment speed j to 1.554. In this case, the result shown in Figure 7 is obtained.

As shown in Figure 7, although each point in the Figure is located near the line

7) Equilibrium solution (NF*, NO*) can be obtained from equations (19i, ii). A detailed consideration is given to the nature and stability of the solution by Matsumoto-Asada (1999).

**Figure 7** A chaotic phenomenon in the firms' industrial park selections




connecting points (0, 4) and (4, 0), they do not converge toward an equilibrium solution. Figure 7 reveals a chaotic phenomenon and does not indicate an equilibrium solution.[8] Chaotic phenomena may be often observed in the selection of industrial parks by the firms, in these cases the number of the firms with type *b* at each industrial park MF, MO is unknown.

As shown in Figure 6, the developer of the industrial parks would more efficiently establish and operate the industrial parks when the developer can know in advance the numbers of the firms with type *b* in the industrial park MF and MO. On the other hand, the case shown in Figure 7 can provide a useful suggestion. A stable equilibrium cannot be obtained in some cases in the selection of industrial park between MF and MO by the firms. The developer of industrial parks might not know the exact number of firms located in each industrial park before the industrial park is concretely planned, then, it is necessary to prepare the second best policy of industrial parks in preparation for such a situation.

### 4.2. Impact on factory's management of agglomeration economies of industrial park

4.2.1. Analysis by specifying the localization economy in industrial park

This subsection deepens consideration of the factory's activity in industrial parks MF and MO using the framework used in the section 3. This subsection deals with the localization economy, which is one of the agglomeration economies. And, it analyzes the effects of the localization economy on the factories located in the industrial parks.[9]

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8) This phenomenon could be chaotic one indicated by Li-Yorke (1975)

9) It is assumed here that the factories with business type *a* and *c* are returned which are temporarily ignored in the analysis in subsection 4.1.

There are two types of localized economies, one of which is an external economic EV that influences on production cost of the factory to reduce the variable production cost. This subsection considers this external economy as follows: The above sections do not include workers in the analysis of the factory's production, this subsection explicitly incorporates the number of workers into production activities. Although workers are not directly involved in the production process, they facilitate the factory's operations smoothly and change variable production cost. And as the number of the workers employed in the industrial park increases, the localization economy changes the variable cost of a factory as shown in equation (22i, ii). Equation (22i) indicates the effect of the localization economy in the industrial park MF near the raw material site, and equation (22ii) shows how the localization economies work in the industrial park MO near the market site.

$$EV_F = -hf*0.05(L_F)^2 + sf(0.05(L_F)) - kf \qquad (22i)$$
$$L_F = N_a*L_a + N_b*L_b$$

where Na is the number of factories with business type *a*, and La is the number of employees employed in factory *1a*. Nb and Lb are the number of the factories and the workers in factory with business type *b*. LF is the total number of workers in the industrial park MF. hf, sf, and kf are parameters that affect the impact of the localization economy in the industrial park MF.

$$EV_O = -ho*0.05(L_O)^2 + so(0.05(L_O)) - ko \qquad (22ii)$$
$$L_O = N_b*L_b + N_c*L_c$$

where Nc is the number of the factories with type c, and Lc is the number of the workers employed in a factory 1c. LO is the total number of workers in the industrial park MO. ho, so, and ko are parameters that affect the impact of the localization economy in the industrial park MO.

Each factory in each industrial park employs workers. Its cost wL is expressed by equation (23i, ii). The labor cost of the factory in the industrial park MF is expressed by equation (23i).

$${}_wL_{fi} = gf(N_iL_i)^{\Phi f} \qquad (23i)$$
$$i = a,b$$

where *gf* and Φ*f* are parameters that affect labor costs. As shown in equation (23i,ii), the labor cost of each factory depends on the number of workers of each business type employed in the industrial park. The labor cost of a factory in the industrial park MO is expressed by equation (23ii). In this equation, *go* and Φ*o* are parameters that affect labor costs in the industrial park MO.

$$ {}_{w}L_{oi} = go\,(N_iL_i)^{\Phi_o} \qquad i = b,c \tag{23ii}$$

The other localization economy, EF, lowers the fixed cost by acting on the equipment of a factory. This external economy changes the fixed cost of the factory as the production volume *TQ* of the industrial park increases by affecting the production infrastructure of the industrial park. The localization economy in this case is expressed by equation (24i, ii). Equation (24i) shows the function of the localization economy in the industrial park MF near the raw material site, and equation (24ii) shows its work at the industrial park MO near the market site.

$$EF_F = -\alpha f(TQ_F)^2 + \beta f(TQ_F) - Df \qquad TQ_F = N_a{}^*mq_a + N_b{}^*mq_b, \tag{24i}$$

where *mqa* is the production amount of the factory *1a* in the business type *a*, and *mqb* is the production amount of the factory *1b*. $TQ_F$ is the total production of the industrial park MF. $\alpha$f, $\beta$f and Df are parameters that affect the impact of localization economy in the industrial park MF.

$$EF_O = -\alpha o(TQ_O)^2 + \beta o(TQ_O) - Do \qquad TQ_O = N_b{}^*mq_b + N_c{}^*mq_c \tag{24ii}$$

where *mqc* is the production amount of the factory *1c* in the business type c, $TQ_O$ is the total production of industrial park MO. $\alpha$o, $\beta$o and Do are parameters that affect the impact of the localization economy in the industrial park MO.

Each factory in each industrial park uses the land in the industrial park and pays the cost *CL*. The cost is assumed to be zero here for simplicity of the analysis.[10)]

Assuming that the localization economy in industrial parks MF and MO functions as directed in Tables 5A and 5B, respectively, the variable and fixed costs for the factory

**Table 5A** Parameters' values of external economies at industrial park MF

| hf | sf | kf | $\alpha$f | $\beta$f | Df |
|---|---|---|---|---|---|
| 0.01 | 4 | 0.2 | 0.0008 | 0.71 | 52.57 |

**Table 5B** Parameters' values of external economies at industrial park MO

| ho | so | ko | $\alpha$o | $\beta$o | Do |
|---|---|---|---|---|---|
| 0.0277 | 2.094 | 0.1 | 0.00156 | 1.46 | 105.14 |

10) Here, land cost CL is set to zero by giving priority to simplicity of the analysis, but, this assumption may partly affect the nature of the conclusions drawn in this analysis.

**Figure 8A** Changes of variable cost due to external economy in industrial parks

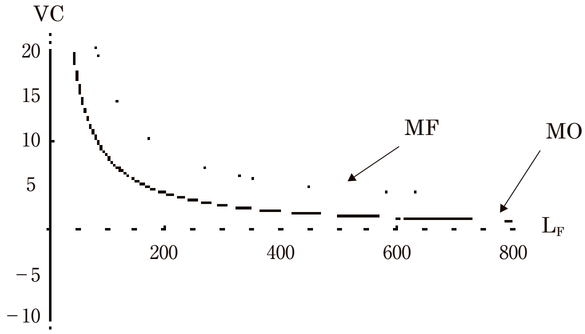


**Figure 8B** Changes of fixed cost due to external economy in industrial parks

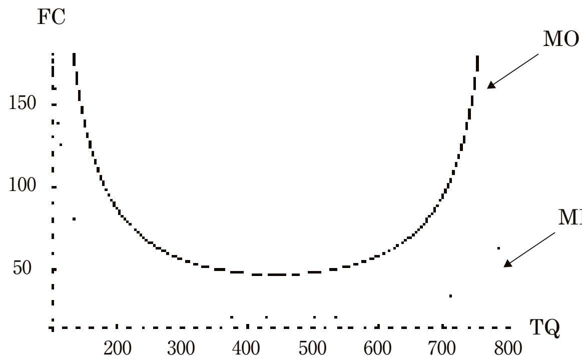


**Table 6** Parameters' values of labor cost at industrial parks

| gf | Φf | go | Φo |
|---|---|---|---|
| 0.6 | 0.15 | 1 | 0.3 |

with type *b* in each industrial park are varied as shown in Figure 8A and 8B.[11] As mentioned above, the industrial park MO is assumed to have characteristics that make workers' activities more advantageous, so the variable cost level in the park MO is lower than that of the industrial park MF. On the other hand, it is assumed that the industrial park MF has the feature of making the function of the production infrastructure more advantageous, so the level of fixed cost in the park MF is lower than that of the industrial park MO.

11） The value of mqb in Table 3 is given to the production amount of the factory *1b*.

Lastly, the factories employ workers and must bear the costs, which vary according to the number of employment in the industrial park, and their variations are determined by the parameters in Table 6.

Then, let us derive the profits of factories in each industry by incorporating the localization economies generated in the industrial parks MF and MO. They are expressed as in equation (25i, ii).[12)]

$$Y_{1Fi} = (1-t)[mq_i((mp_i - t_g d_4) - (p_3 + t_e d_3)) - (2mq_i^{1.25}(A_i)^{-1.25}(p_1 + t_m d_1)^{0.5}(p_2 + t_m d_2)^{0.5})/EV_F - F_1/EF_F - gf(Ni^*Li)^{\Phi f} - CLf] \quad i = a, b \tag{25i}$$

$$Y_{1Oi} = (1-t)[mq_i((mp_i - t_g d_4) - (p_3 + t_e d_3)) - (2mq_i^{1.25}(A_i)^{-1.25}(p_1 + t_m d_1)^{0.5}(p_2 + t_m d_2)^{0.5})/EV_O - F_1/EF_O - go(Ni^*Li)^{\Phi o} - CLo] \quad i = b, c \tag{25ii}$$

Finally, the following assumptions are made to analyze the impact of the localization economy of industrial parks on factory's activity. Each factory determines the number of workers it employs to maximize factory profits. And industrial park developer decides the number of factories in each industry to maximize the profit of each firm.[13)]

4.2.2. Derivation of profit of factories located in industrial parks

This subsection specifically derives the profits of the factories located in the industrial parks MF and MO. Using the results of the analysis in the previous section, the production volume and the transfer price of factories belonging to each industry are given as follows. The production volume and the transfer price of a factory with business type *a* is $mq_a = 49.19$, $mp_a = 442$ . The production volume and the transfer price of a factory with business type *c* is $mq_c = 49.09$, $mp_c = 442.5$. And when the factory with type *b* is located in the industrial park MF, the production amount and the transfer price of a factory are $mq_b = 49.09$, $mp_b = 442.5$, and the production amount and the transfer price when the factory is located in the industrial park MF are $mq_b = 48.97$ and $mp_b = 443$.

Under the above assumptions, the number of the factories located in each industrial park and the number of the workers employed by the factories are derived. First, derive the number of the factories and the workers of the firms with business type *a* and *b* located in the industrial park MF. These values are obtained by solving the simultaneous equations consisting of four equations (26i ～ iv) for Na, Nb, La, and Lb. The numbers of

12) The profit of the factory *2* in charge of process *2* is fixed, so if the profit of factory *1* is maximized, the profit of the firm is maximized. Therefore, the analysis focuses on the factory *1*.

13) It should be notified that the industrial park developer does not determine the number of the factories in each industry to maximize the total profit generated in each industrial park.

**Table 7A** The numbers of factories and workers of a firm at industrial park MF

| $N_b$ | $L_b$ | $N_a$ | $L_a$ |
|---|---|---|---|
| 4.25 | 51.36 | 5.27 | 41.33 |

**Table 7B** The numbers of factories and workers of a firm at industrial park MO

| $N_b$ | $L_b$ | $N_c$ | $L_c$ |
|---|---|---|---|
| 3.79 | 119.5 | 5.3 | 95.2 |

the factories and the workers of the factories with type *c* and *b* located in the industrial park MO are derived in the same way.

$$\partial Y_{1a}/\partial N_a = 0 \quad (26i)$$
$$\partial Y_{1b}/\partial N_b = 0 \quad (26ii)$$
$$\partial Y_{1a}/\partial L_a = 0 \quad (26iii)$$
$$\partial Y_{1b}/\partial L_b = 0 \quad (26iv)$$

The optimal number of the factories and the number of the workers employed in each factory are shown in Tables 7A and 7B, respectively.

The composition of production activities in the two industrial parks shown in Table 7A and 7B differs depending on the characteristics of the industrial parks. The number of the workers in the industrial park near the market site is much higher than that in the raw material. This is consistent with the industrial parks' characteristics suggested in the previous section. On the other hand, the number of the factories is higher in the industrial park near the raw material, which does not successfully match the characteristics suggested in the previous section. This may be related to the fact that the cost of land use in industrial parks is assumed to be zero in this analysis.

From the above Table 7A and 7B, the factory profit $Y_1$ of each business type and the profit Y of each firm in the industrial parks MF and MO are obtained. They are shown in Tables 8A and 8B.

When there is no localization economy, the factories with business type *b*, are in a position to select either industrial park MF or MO. Incorporating localization economy produced by each industrial park, the factories with type *b* can enjoy the provided localization economy and conduct production. the factories in industrial park located near the market site gain a little high profit. However, the difference in profits is narrow due to the optimization behavior of the factories and the developer of the industrial parks. It cannot be said that the industrial park MO is decisively advantageous to the firms with type *b*. In addition referring the results shown in subsection 4.1, it can be considered that

**Table 8A** Profits of factories and firms in the industrial park MF

| type | a | b |
|---|---|---|
| $Y_1$ | 3899 | 3879 |
| Y | 4415 | 4387 |

**Table 8B** Profits of factories and firms in the industrial park MO

| type | b | c |
|---|---|---|
| $Y_1$ | 3894 | 3897 |
| Y | 4396 | 4405 |

**Table 9** Total profits and workers of the industrial parks

| park | MF | MO |
|---|---|---|
| TY | 41919 | 40008 |
| TW | 436 | 958 |

the factories with type *b* are located separately in industrial parks MF and MO.[14)]

Finally, from the above Tables, the total profit TY and the total number TW of the workers in the two industrial parks are derived. They are shown in Table 9. As shown in Table 9, the total profit of the industrial park MF is larger than that of the industrial park MO. The industrial park MF is more advantageous than the MO for the developer of the industrial park.

The results of the analysis in section 4 can be summarized as follows. Industrial parks prepare their production infrastructure to create an external economies that matches the characteristics of its location place. A firm planning a location of factory selects an industrial park that matches the characteristics of the factory. However, the firms' selection is not always unique, and the selection of industrial park by the firms could be divided. A chaotic phenomenon may provide a case that the firms cannot uniquely determine the industrial park for their factories. The compositions of the production activities of the industrial parks are different between industrial parks, while, they have the partly similar character as other industrial parks.

## 5. Concluding remarks

Industrial park can intentionally attract many factories from foreign countries to

14) It should be noticed that the developer of the industrial park determines the number of firms so as to maximize the profit of each firm.

specific points in a country using agglomeration economies. An industrial park, thus, has been evaluated as an important means in government's economic policy. This paper theoretically analyzed how location and production structure of industrial park is affected by location factors activated by the government's economic policy.

The essential point revealed in this paper is as follows. It is a private firm that decides the location of the factory, and the success or failure of the industrial park depends on the private firms. However, the government has a reasonable ground for direct and indirect intervention in the decision of where to establish an industrial park. This paper shows, using the concept of Location Prospective Area, that location of industrial park is not limited to a specific site, but it can be located within a certain geographical range in a country. It implies that the regional government can play a certain role in determining the location of industrial park within the geographical range indicated by LPA. And also, the national government can play a certain role in determining the location of industrial park by using the policies of a reduction of the corporation tax rate and a decrease of the freight rates which can affect the position of the LPA. And then, this paper, assuming that the government as a developer of industrial park constructs two industrial parks, shows how the firms select an industrial park out of the two parks which have different characteristics in production conditions, and it clarifies that the firms' locations are divided between the two industrial parks in a certain ratio, though in some cases chaotic phenomenon affects the firm's industrial park selections. Lastly, the analysis shows the effects of localization economy on the firms' production cost and profits: It clarifies that if the developer of the industrial park and the individual firms act to optimize the number of the factories and the number of the workers employed based on the characteristics of the industrial parks, the firms' profit gap between the industrial parks is not so large. And while the composition of the production structure of an industrial park differs depending on the industrial park, it is often the case that it has characteristics partially similar to other industrial parks. It is expected that the interesting theoretical conclusions presented here are worth validating by empirical analyses.

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