Influence of location factors activated by economic policy on industrial park

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1 Introduction

The progress of the globalization economy has intensified international price competition among manufacturing firms, especially, the firms belonging to the assembly machinery industry. Prices of products of this industry depend heavily on production costs, thus, price competition raises the cost cutting competition. In order to reduce costs, many manufacturing firms fragment production processes and distribute the fragmented processes to countries and regions where labor costs are lower. Each subdivided production process are linked other production processes by logistics, finance, and information function. Therefore, the fact that each process can be dispersed spatially gives the opportunities for the many governments to attract the production processes to their countries, but unless the basic production infrastructure as described above is developed, the countries cannot attract the fragmented processes.

The fragmented production processes are relatively small, and their production contents become simplified. Therefore, when attracting these production processes, a relatively small infrastructure is sufficient to attract these processes. In this context, it may be considered that industrial park can be used as a powerful means to attract the processes. The establishment of industrial parks has been evaluated in many countries as an important means of economic development policy.

Industrial park cannot lead uniformly the production processes of all business types. Depending on the industrial park's nature, the business types of the tenants of the park vary greatly. Therefore, when the government establishes an industrial park, it must plan carefully the production mode and location of the industrial park, taking into consideration the industrial economic structure, the economic development stage of the area, and the economic structure oriented. This paper analyzes the location and production composition of industrial park, from the viewpoint of the location theory[1].

The structure of this paper is as follows. The section 2, from the viewpoint of traditional location theory, describes how the transportation cost and agglomeration economies affect factory's location, and it explains how industrial park is suitable to attract factories, and it is useful to as a means of economic policy. Section 3 builds a model for location determination of a firm operating two production processes. Using this model, it is examined how the location of the industrial park is determined. In addition, this model shows that regional government has an opportunity to influence the park's location by considering the regional economic conditions. And then, it analyzes the

[1] The policy of the industrial estate contains various purposes. The formations of a simple production district and urban formation are included in the target of this policy (See Bredo,1960).

locational power of factors activated by national government on industrial park; it is shown that the corporation tax rates and the freight rates have power to change the industrial park's location. Section 4 assumes that the government becomes a developer of industrial park, and it analyzes the relationships between characteristics of industrial park and its location incorporating agglomeration economies generated in the park into the analysis. Section 5 examines the economic significance of the government's investment into infrastructure in surrounding area of the industrial park by the government. The analysis in this section shows that improvement of infrastructure in the surrounding area of the industrial park would not be supported from the viewpoint of profits; while, from another viewpoint of employment, it is highly evaluated: It is pointed out that the government's economic policy should be evaluated from multiple perspectives. Section 6 summarizes the results of analysis in this paper.

2 The effect of industrial park on factory's location

According to A. Weber (1909) , this section examines how general location factors affect factories. From the perspective of industrial location theory, the examination clarifies how the 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 almost all factories are classified into the group of the general location factor, whereas the factors influence only on specific factories are classified as special location factor.

As the former general location factor, transportation costs, labor costs, and 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 his viewpoint factors are classified into directional location factor and agglomeration factor. The former means that the factors acting to lead a factory to a specific point, such as exemption of property taxes and the provision of subsidies granted to the factories by the 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 invitation 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. Establishment of an industrial park is a 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 framework are introduced as follow[3]. A firm produces 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 market place 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),

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[2] Various kinds of industrial parks are described by Pose-Hardy(2014)。

[3] The analysis framework is constructed according to Weber (1909), Puu (1998) and Ishikawa (2016). 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).

$$Y_1 = (1- t)[\ mp * mq - C(mq) - F_1] \qquad (1)$$

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.

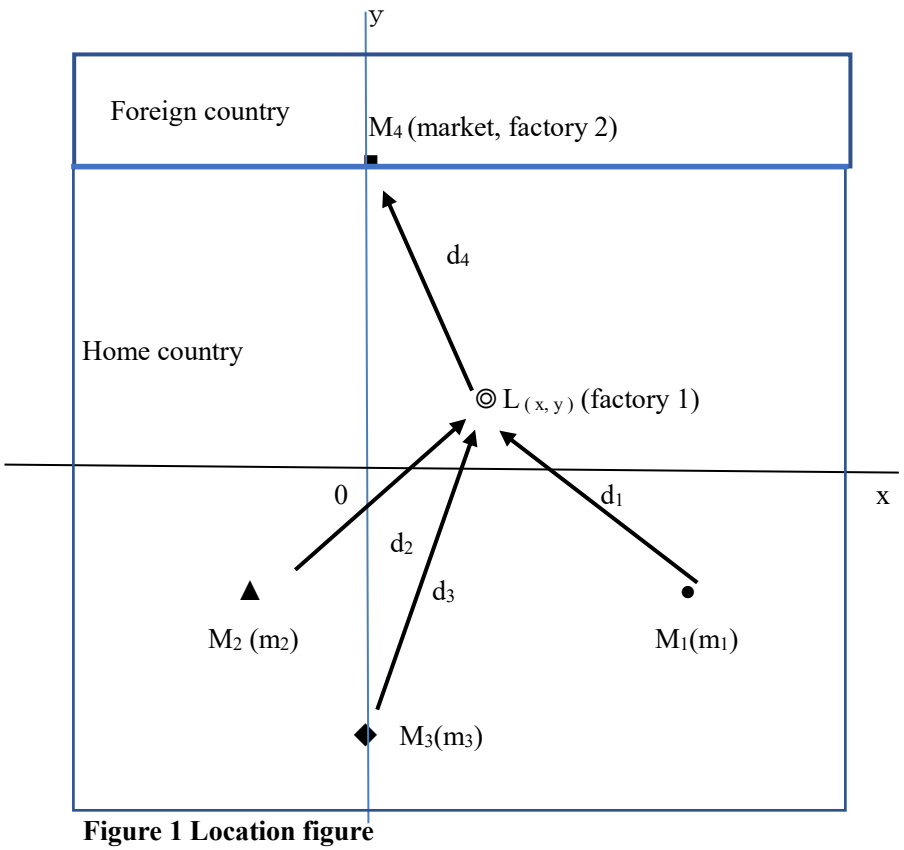


Figure 1 Location figure

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, α and β are parameters and they are defined as A>0, 0< (α+β) <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:

$$P_1 = p_1 + t_m d_1 \quad (4a)$$
$$P_2 = p_2 + t_m d_2 \quad (4b)$$
$$P_3 = p_3 + t_e d_3 \quad (4c)$$

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),

$$DP = mp - t_g d_4 \quad (5)$$

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, α and β are assumed α=β=0.4):

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

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

$$m_3 = mq \quad (6c)$$

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

$$C(mq) = 2A^{-1.25} mq^{1.25} (p_1 + t_m d_1)^{0.5} (p_2 + t_m d_2)^{0.5} + mq (p_3 + t_e d_3) + F_1 \quad (7)$$

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

$$Y_1 = (1-t) [mq ((mp - t_g d_4) - (p_3 + t_e d_3)) - 2mq^{1.25} A^{-1.25} (p_1 + t_m d_1)^{0.5} (p_2 + t_m d_2)^{0.5} - F_1] \quad (8)$$

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),

$$p = a - vQ \quad (9)$$

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),

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

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

$$C(Q) = \gamma Q(\delta + Q)^2 / \varepsilon \quad (11)$$

where parameters γ, δ, ε 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),

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

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),

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

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),

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

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.

$$\begin{aligned} Y=&(1-t)[(0.22(-206+(582409-900mp)^{0.5}))((mp-t_g d_4)-(p_3+t_e d_3))- \\ &-2(0.22(-206+(582409-900mp)^{0.5}))^{1.25}A^{-1.25}(p_1+t_m d_1)^{0.5}(p_2+t_m d_2)^{0.5}-F_1] \\ &+(1-t^*)\,[(600-(0.22(-206+(582409-900mp)^{0.5}))-mp)(0.22(-206+ \\ &(582409-900mp)^{0.5}))-F_2]. \end{aligned} \quad (15)$$

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.

$$x_{n+1}=x_n+j*\partial Y/\partial x, \quad (16a)$$

$$y_{n+1}=y_n+j*\partial Y/\partial y, \quad (16b)$$

$$mp_{n+1}=mp_n+j*\partial Y/\partial mp, \quad (16c)$$

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 $t=t^*=0.82$.

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

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

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

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 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.

[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.

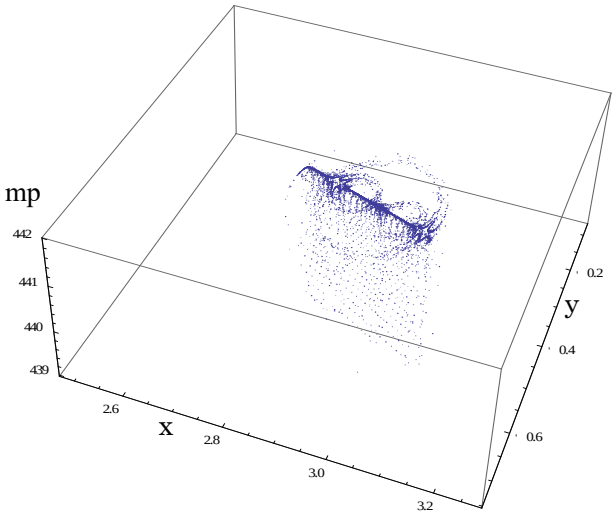


Figure2A Position of chaotic area in low freight rate

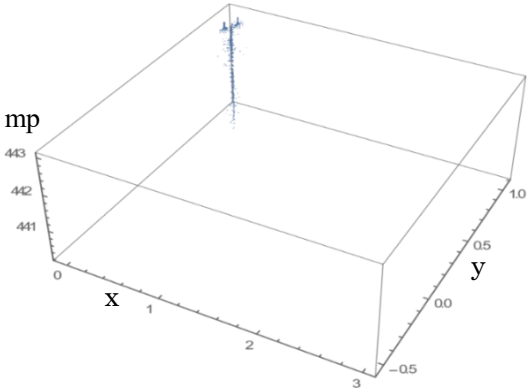


Figure2B Position of chaotic area in high freight rate

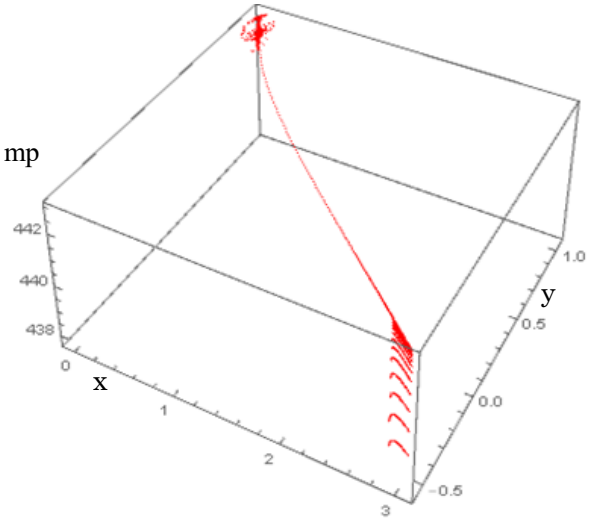


Figure2C Position of chaotic area in moderate freight rate

Table1 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 imprecation of chaotic area

The chaotic phenomenon has an interesting locational imprecation 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 reduce significantly 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

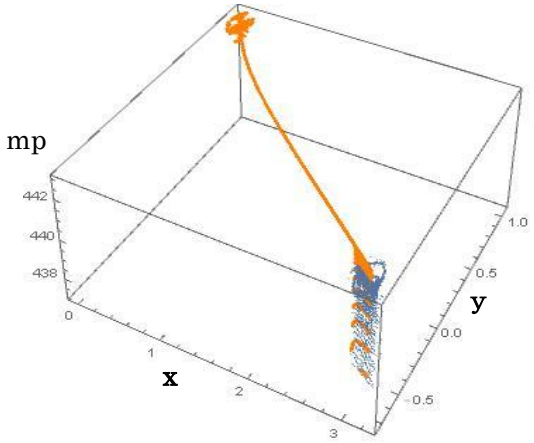
3.5.1 The basic idea of determination method of location and composition of industrial park

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.

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

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.



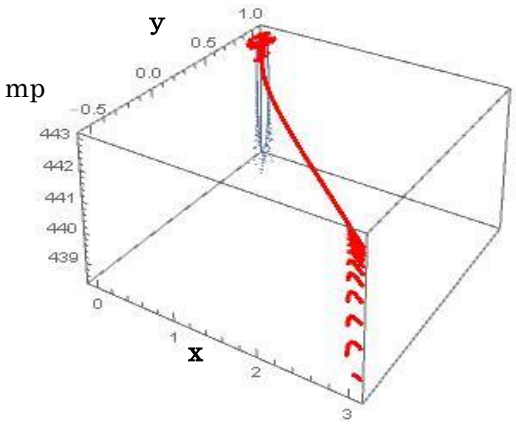


Figure 3A Overlapping area around point M_1 **Figure 3B Overlapping area around point M_4**

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 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 *1a, 1b* 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.

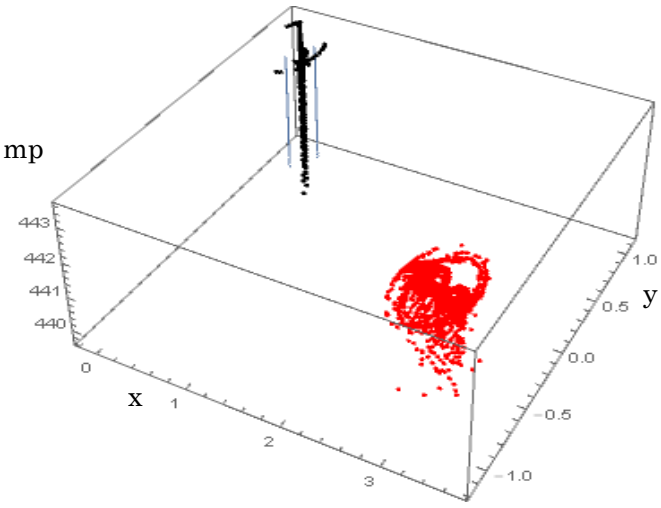


Figure 4 Formation of industrial park at point M_4

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.

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

In this case, the LPAs of all factories are generated around point M_1. Overlapping area 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_4 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.

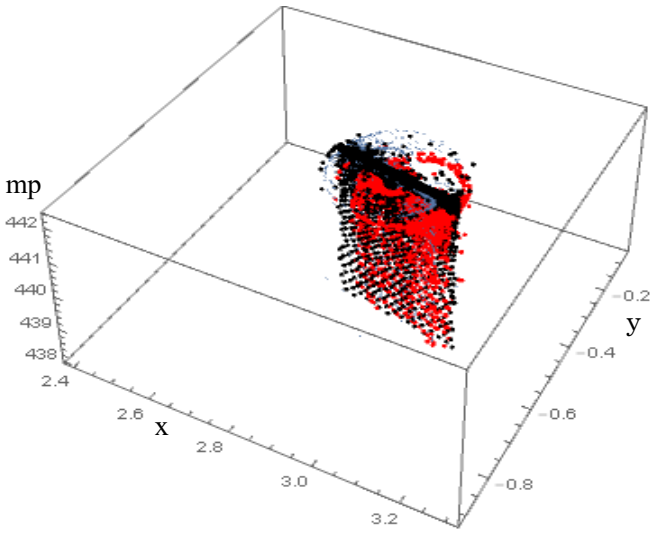


Figure 5 Formation of industrial park composed by three factories at point M_4

4 Relationships between industrial park's characteristics, location and production composition

Among economic policies by the governments the following policy is included; the government becomes a developer of industrial park and exercises its economic power directly to the regional economy. This subsection takes up this policy and analyze the relationships between industrial park's characteristics, location and production composition.

4.1 Additional assumptions for analysis of industrial park

Let us suppose that the government has a project to establish an industrial park, and its project assumes two kinds of industrial parks with different natures, *type I, type II*. The purpose of this section is to analyze the location of each of two different industrial parks.. For this analysis the following assumptions are added:

(1) Location of the industrial park is confined into the two points, M_1 and M_4.

(2) Based on the results derived in the previous section, if industrial park is constructed at point M_1, the combination of business types of the tenants is confined into the combination of type *a* and type *b*: And if industrial park is established near point M_4, the combination is *b* and *c*.

(3) The number of the factories in an industrial park is not limited to two. The number of factories in each business type, N_i (i=a, b, c,), within the industrial estate is determined by the government as a developer of the industrial park to maximize the profit of each factory.

(4) Each factory employs workers (L_i, i=a, b, c) to operate the factory as a whole. The number of workers of factory is determined by the factory to maximize the factory's profit.

(5) Industrial park provides two different kinds of external economies which are essential to industrial parks: One of external economies (EEv) reduces the factory's variable cost, and the extent

to which the economies reduce the cost is a function of the numbers of workers employed in the industrial park. Equation (18) shows the function of EEv.

$$EE_{VI} = -h(0.05(TL_I)^2 + j(0.05(TL_I)) - k \quad (18)$$

$$I=M_1, M_4$$

$$TL_{MI} = N_a*L_a + N_b*L_b \,,\; TL_{M4} = N_b*L_b + N_c*L_c$$

where TL_I ($I=M_1, M_4$) is the number of workers in the industrial park, and *h, j,* and *k* are parameters which indicate the works of the external economies, EEv. Labor cost borne by a factory is a function of the number of workers who are employed in *each business type*; labor cost of the factory ${}_wL$ with each business type is indicated by equation (19)

$${}_wL_i = g(N_iL_i)^{\Phi} \quad (19)$$

$$i=a,b,c$$

where N_iL_i is the number of workers employed by all factories of the business type *i* (i=a, b, and c), g is parameter and Φ is the parameter which influences the rise in labor cost caused by the increase of workers.

(6) Another external economies (EE_F) reduces the factory's fixed cost, and the extent to which the external economies reduce the fixed cost is a function of the total quantity (TQ) produced in the park. Equation (20) shows the function of the external economies of EE_F,

$$EE_{FI} = -\alpha(TQI)^2 + \beta(TQI) - D \quad (20)$$

$$I= M_1, M_4$$

$$TQ_{MI} = N_a*mq_a + N_b*mq_b, \; TQ_{M4} = N_b*mq_b + N_c*mq_c$$

where α, β, and D are parameters. When industrial park is constructed near point M_1, TQ is shown by TQ_{MI}, while, if the park is constructed near the market place, TQ is given by TQ_{M4}. In this subsection, it is supposed that the fixed cost contains not only the costs which are directly related with production of goods but the overhead costs of training of workers, guest accommodation, catering and so on.

(6) Lot size for every factory in industrial park is the same. The land cost (CL) borne by every factory is given. The cost is assumed to be zero for simplicity of the analysis.

(7) Production amount and transfer price of each factory is determined in the same way used in the previous section. Therefore, minimizing the production costs is compatible with maximizing profit of the firm.

(8)Although the cost of construction of industrial park by the government is implicitly assumed,

it is not incorporated explicitly into the analysis because it does not essentially affect the purpose of this analysis of industrial park.

4.2 Derivation of the number of factories and production composition in industrial park

By referring the analysis in the previous section, profit of individual factories with each type is given by equation (21),

$$Y_{1i}=(1-t)[\, mq_i\,((mp_i-t_g d_4)-(p_3+t_e d_3))\,)- (2mq_i^{1.25}\,(A_i)^{-1.25}(p_1+t_m\,d_1)^{0.5}(p_2+t_m\,d_2)^{\,0.5}\,)/EE_v- F_1/EE_F- g(Ni*Li)^{\Phi}-CL] \quad i=a,b,c \qquad (21)$$

And from the results in the previous section, production amount and transfer price of the factory 1_a are obtained that $mq_a=49.19$, $mp_a=442$, and also those of the factory 1_c are given as $mq_c=49.09$, $mp_c 442.5$; and if the factory 1_b locates in industrial park established near point M_1, production amount and transfer price are $mq_b=49.09$, $mp_b=442.5$; while, when the factory 1_b locates in industrial park near point, M_4, they are given as $mq_b=48.97$, $mp_b=443$. Based on these results, the production composition of each industrial park is analyzed.

The government as a developer of an industrial park near point M_1 determines the numbers of the factories, 1_a and 1_b. And each kind of firms decide the number of workers employed in its factory to maximize its profit. Thus, the number of each kind of factories and the number of workers of each factories in the industrial park of type I which is established near point M_1 are derived by solving equation system (22_i, i=a, b, c, d) with respect to N_a, N_b, L_a, and L_b,

$$\partial Y_{1a}/\partial N_a = 0 \qquad (22a)$$

$$\partial Y_{1b}/\partial N_b = 0 \qquad (22b)$$

$$\partial Y_{1a}/\partial L_a = 0 \qquad (22c)$$

$$\partial Y_{1b}/\partial L_b = 0 \qquad (22d)$$

In the same way, the numbers of the factories, 1_b and l_c and the numbers of workers in each factory in the industrial park near point M_4, are obtained.

4.2.1 The number of factories and production composition in industrial park of type I

Now, the industrial park of type I which is planned by the government has the characteristics which are indicated by parameters' values in Table 5. The parameters in the Table 5 define the two kinds of external economies generated in the industrial parks.

Table 5 Parameters' values that define external economies and labor cost in the Type I

h	j	k	α	β	D	g	Φ
0.01	4	0.2	0.0008	0.71	52.57	0.6	0.15

The real curve in Figure 6A shows how the variable cost VC of factory *1b* located at industrial park of type I at point M_1 change due to external economy, EEv_I.

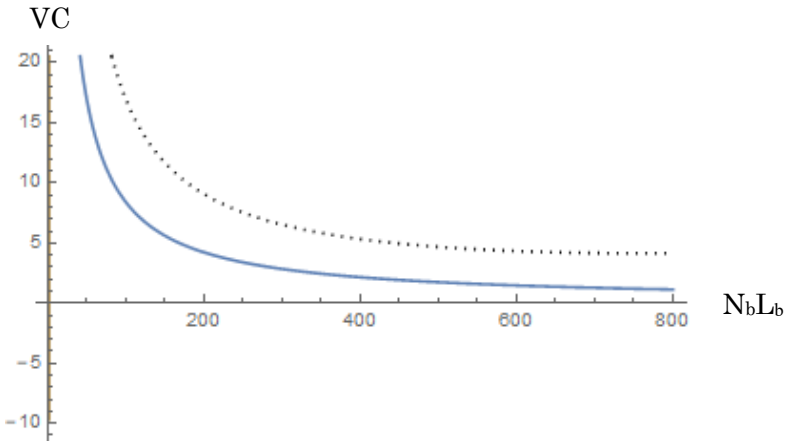


Figure 6A Variation of variable cost due to external economy in industrial park

The real curve in Figure 6B shows how the fixed cost FC of factory *1b* located at industrial park of type I change due to external economy, EE_{FI}.

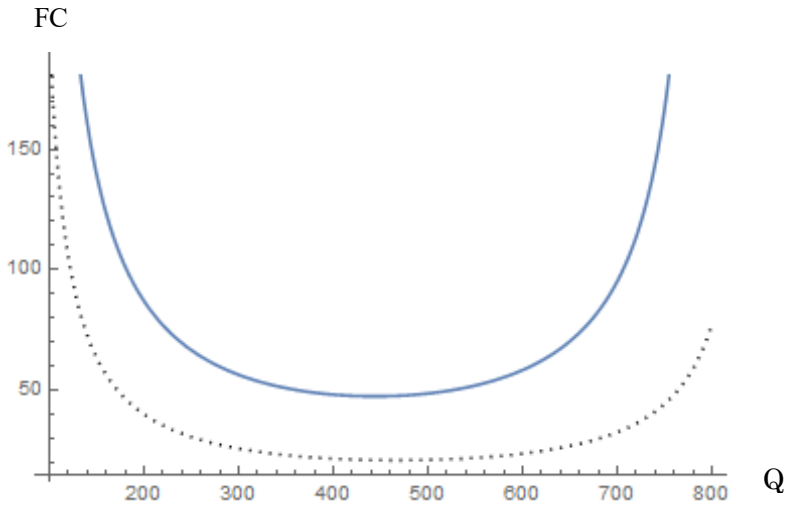


Figure 6B Variation of fixed cost due to external economy in industrial park

Let us derive the number of each kind of factories and the number of workers of each factory in the industrial park of type I near point M_1. Solving equation system (22_i, i=a, b, c, d) with respect to N_a, N_b, L_a, and L_b gives the production composition of the park of type I at point M_1. The production composition is indicated in Table 6A.

Similarly, the production composition of the park near point M_4 is indicated in Table 6B. The comparison of production compositions in the two industrial parks that are shown in Table 6A and 6B indicates that even if the industrial park to be constructed at the two different points is same in size and quality, the production composition and profits generated in the parks become different. Their differences are created by the characteristics of the factories which co-exist in the industrial park.

Table 6A The numbers of factories and workers of firm at industrial park at point M_1

location	N_b	L_b	N_a	L_a
M_1	3.74	121.4	5.29	85.23

Table 6B The numbers of factories and workers of firm at industrial park at point M_4

location	N_b	L_b	N_c	L_c
M_4	3.79	119.5	5.3	95.2

By using the numbers of the factories and the workers employed by the factories in each industrial park shown in Table 6A and 6B, the profits of the three kinds of the firms can be obtained in each industrial park. Table 7A shows the profits of the three firms for industrial park of type I with different location sites. Table 7B shows the total profits, TY, and total number of laborers, TW, of industrial park of type I with the two location sites.

Table 7A Profits of the three kinds of firms in the industrial park of type I with different points

	factory*1a*	factory *1b*	factory*1b*	factory *1c*
location	M_1	M_1	M_4	M_4
Y_1	3896	3876	3894	3897
Y	4412	4384	**4396**	4405

Table 7B Total profits and workers of the industrial park of type I with different points

location	M_1	M_4
TY	39735	40008
TW	905	958

Whether or not to locate in the industrial park in question depends on the judgment of the individual firms. Therefore, when the industrial park of the type I is constructed, firms *b* prefer industrial park located near point M_4. Referring the judgment of firms b, the government establishes the industrial park of type I near point M_4. Nevertheless, the government as a planner of regional economic policy and a developer of industrial park pays attention to total profits and total number of laborers of the industrial park of type I with different points. As shown by Table 7B, since the industrial park located near point M_4, provides more gross profits and more employments than those obtained at point M_1, The establishment of industrial park of type I at point M_1 is seconded by the two economic agents , private firms and the government.

4.2.2 The number of factories and production composition in park of type II

This subsection assumes that the government considers establishment of the industrial park of type II. Table 8 shows the external economies provided in the industrial park of type II and labor cost.

The dotted curve in Figure 6A shows how the fixed cost VC of factory *1b* located at industrial park of type II at point M_1 change by external economy, EE_{VI}. The dotted curve in Figure 6B shows how the fixed cost FC of factory *1b* located at industrial park of type II change by external economy, EE_{FI}. It can be said that the type II industrial park has characteristics that reduce more the fixed cost, while, the variable cost is not reduced much as compared with the park of type I. Table 8 describe the nature in production of the park of type II.

Table 8 Parameters' values indicating external economies generated by the park of type II

h	j	k	α	β	D	g	Φ
0.0277	2.094	0.1	0.00156	1.46	105.14	1	0.3

Let us examines where the industrial park locates referring the parameters' values shown in Table 8. The numbers of each kind of the factories and workers employed by each factory in the both points M_1 and M_4 are derived as indicated in Table 9A and 9B.

Table 9A The numbers of factories and workers of firm at industrial park at point M_1

location	N_b	L_b	N_a	L_a
M_1	4.25	51.36	5.27	41.33

Table 9B The numbers of factories and workers of firm at industrial park at point M_4

location	N_b	L_b	N_c	L_c
M_4	2.43	46.23	7.11	53.89

By using these numbers of the factories and the workers, the profits of the three kinds of firms can be derived for the industrial park of type II to be constructed at the two points M_1 and M_4. They are shown in Table 10. Since the factories 1_b surely select the industrial park of type II at point M_1 at which the factories 1_b can obtain higher profits than that the park located near point M_4: The industrial park of type II is constructed by the factories 1_a and the factories 1_b at point M_1. Table 10B shows the total profits TY and total number of laborers TW of industrial park of type II with different locations.

Table 10A Profits of the firms in the industrial park of type II located at different sites

	factory 1_a	**factory 1_b**	**factory 1_b**	factory 1_c
location	M_1	M_1	M_4	M_4
Y_1	3899	3879	3859	3902
Y	4415	**4387**	4361	4410

Table 10B Total profits and workers of the industrial park of type II with different points

location	M_1	**M_4**
TY	41919	**41942**
TW	436	**495**

It can be said the location and production composition of the industrial park changes vary by the characteristic of industrial park. And the comparison of Table 10A and 10B provides an interesting fact that from the viewpoint of the government, industrial park near point M_4 would be more attractive since the gross profit and total employments of the park are larger than those of the park near point M_1. In principle, it is the firm that ultimately decides the location of the factory, hence, the location of the industrial park is decided at point M_1. However, with respect to the location of the industrial park of type II, there is difference in perspective between the firms and the government, because the industrial park located near point M_4, provides more gross profits and more employments than those obtained at point M_1. There would be a possibility of discussion and negotiation on subsidies and exemptions of tax rates between the firms and the government. Considering the government's mission and the purpose of the firms, such the discussion and the negotiations will be economically valuable.

5 Significance of improvement of infrastructure in surrounding area of industrial park

This section analyzes the economic effects of labour costs on production mode in industrial park. In this analysis it is clarified that there is the motivation for the regional development policy to improve the social infrastructure in the surrounding area of the industrial park.

5.1 Changes in production mode of industrial park by improvement of social infrastructure

Economic policy by the government includes various purposes. Among them are the increase in local employment as well as the increase in profits of firms in the region. From this point of view, it is considered from the result obtained in the previous section that the industrial park's location at the point M_1 does not sufficiently achieve the primary purpose of the government's economic policy. In this context, from the viewpoint of labor cost which is one of general location factors, there might be the following means as a method for the government to sufficiently achieve one of goals of its economic policy, the increase of employment in a region:

1) The government invests in social infrastructure around industrial park.
2) Improvement of social infrastructure has the effect of expanding commuting area to industrial park.
3)The expansion of the commuting area increases the capacity of worker supply and it suppresses increase of labor cost in industrial park.
4) Lower labor cost leads to increase the number of employments in the industrial park

This section supposes that the government's policy of improving social infrastructure around the industrial park restrains the rise in labor cost in the industrial park. And this section analyzes the effectiveness of this scenario. For this end, reducing value of parameter Φ, which affects the level of the labor cost which is varied according to the number of workers in the industrial park, from 0.3 to 0.1 due to investment by the government into social infrastructure, this section analyzes profits of individual firms *a* ,*b*, total number of employees, and total profits in the park located at point M_1.

When the parameter Φ is reduced to 0.1, the production composition of the industrial park is shown by the Table 11. Using this result, profit of individual firms *a*, *b*, total number of employees, and total profits in industrial park can be obtained. They are shown by Table 12.

Table 11 The numbers of factories and workers in industrial park of type II near point M_1

location	N_b	L_b	N_a	L_a
M_1	3.69	97.9	5.83	61.84

Table 12 Changes of profits and workers in industrial park due to reduction of Φ

Φ	0.3	0.1	rate of change
Y_a	4415	4420	0.1%
Y_b	4387	4388	0.02%
TY	41919	41954	0.08%
TW	436	722	**66%**
TQ	468	468	**±0%**

5.2 Economic significance of improvement of infrastructure in the area adjacent industrial park

Table 12 shows interesting conclusions: This measure to curb the increase in labor costs does not substantially increase the profit of individual firms and the total profits of the industrial park compared with those obtained when the parameter Φ is 0.3. And in this case the total production amounts, TQ, in the industrial park are not increased. From the viewpoint of profit and employment, therefore, this investment policy may be failure. However, the number of employees in the industrial park increases by 66% by this investment policy. Given that the increase in employment in the region is one of primary goals of governmental economic policy, this investment achieves the purpose of increasing employment in the region. This government policy, thus, should be highly evaluated[6].

6 Concluding remarks

Industrial park can intentionally attract multiple factories from outside areas to a specific point in region using agglomeration economies. The industrial park, therefore, has been evaluated as an important means in the government's regional economic policy. This paper theoretically analyzed how location and production composition of an industrial park is established and changed through location factors activated by the government's regional economic policy.

First, this paper shows, using the concept of Location Prospective Area, that location of the industrial park is not limited to a specific site, but it can be located within a certain geographical range. It points out that the policy of regional governments can play a certain role in determining the location of industrial park within this geographical area. Subsequently, it is shown that the national government’s economic policy, such as reduction of the corporation tax rate and a decrease of the freight rates due to large-scale investment in the transportation system affect the position of the LPA where the location of the industrial park is determined.

Then, the relationship between the characteristics of industrial park and its location is analyzed, and the relationship is clarified. Due to the differences in the nature of the external economy created by the industrial estate, the site of the park and its production style vary greatly. In addition, the following economic aspect is introduced in this analysis: in the case where the government develops an industrial park, the evaluation of the government and the firm's evaluation do not necessarily agree on the location of the industrial park.

In the final analysis, it is supposed that the government’s investment in social infrastructure in the area adjacent to the industrial park may widen the commuting area of the industrial park and suppresses the rise in the labor costs in the park. Under this supposition, it is analyzed how reduction of labour cost changes the production style of industrial park. The analysis reveals that policy that curbs the rise in labor costs hardly increase the profits of industrial park, but it greatly increases employment in the park. From this analysis the following conclusion is drawn: If one of the objectives of the

[6] In the analysis here, the cost aspect required for government investment is ignored.

government's policy is to increase employment in the region, even if the government's investment does not lead directly to the increase of profits, this investment policy should be appreciated.

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