A theoretical analysis on location and production composition of industrial park

Toshiharu Ishikawa

1 Introduction

The economic globalization gives rise to a harsher price competition among manufacturing firms, and it leads to a cost cutting competition in the manufacturing industry. To cope with the economic globalization many manufacturing firms fragment their production processes into small blocs. These fragmented small production processes are scattered across nations' borders to the places which bring lower production costs to the manufacturing firms. The places which attract the fragmented processes from foreign countries usually possess favorable production condition suitable to the contents of the production processes. And these places are equipped with adequate infrastructure enough for firms to operate their factories smoothly. In this context, industrial parks are highly reevaluated by the manufacturing firms and the governments of many countries: Since an industrial park is built in consideration of characteristics and quality of the factories being induced to the park, industrial park surely provides the factories with appropriate external economies in the park. Thus, when the manufacturing firms determine a factory's location in a region, they naturally consider industrial park as an important location factor in searching site for a new factory. While, the government planning to vitalize regional economy in a certain region by attracting factories often use an industrial park as one of economic tools to accomplish the end. Because the government can develop an industrial park to agglomerate factories at a place and to induce them to a specific site in the region. In addition, an industrial park manages various sorts of office and business functions through IT and ICT technologies so that both manufacturing firms and government can proceed their works speedily. The fact that industrial park makes the firms' management works smoother is one of merit of industrial park. Based on these reasons, it is considered among economic agents that since an industrial park has strong possibility to influence regional economy in several ways, regional economic agents such as regional administration and regional industries concern industrial park's location and its composition.

This paper theoretically analyzes following three issues. First, the paper clarifies the concept of the location prospective area in which industrial park is likely to be established through the analysis of firm's location selections, and then, by using this concept the business types of the factories which are co-presence in an industrial park are derived. Second, this paper examines the effects of external economies generated in industrial park on the profits and the numbers of the factories with different business types. Lastly, the frame work of the analysis is expanded to cover the influences of urbanization economies. Urbanization economies are generated outside industrial park and they affect industrial park's location and production composition through the interaction with external economies inside the park. The effects of urbanization economies on the production composition of the industrial park are clarified in this analysis. In addition, it is shown in this analysis that the reduction of the wage

rates in the industrial park due to expansion of the commuting area of workers by the government's investment does not always make the profit of every factory higher because of the change of the production composition in the industrial park.

Present paper is organized as follows: Section 2 explains assumptions and framework of analysis and derives the firm's profit function. Using the firm's profit function, the locational prospective area is derived by the chaotic phenomena. And the usefulness of this concept is elucidated by explained that the location prospective area specifies the spatial range for a firm searching the site of a new factory. And then, expanding this analysis to cover two factories' locations, combination of the business types of the factories which co-exist in the same industrial park are derived. Section 3 shows how external economies generated in industrial park affect the production component of the park. In section 4 urbanization economies are introduced into the analysis. Considering urban economies generated by cities with different size, it is examined how performances and production composition of an industrial park vary by the size of the city in which the industrial park locates. In addition, the effects on the firms' profits of an investment aiming to reduce the wage rate of workers in industrial park is analyzed. Section 5 summarizes the results derived from the analysis.

2 Derivation of location and composition of industrial park by location analysis of factories

2.1 Assumptions and framework of analysis

According to the traditional location theory assumptions and framework are introduced as follows[1].

A firm produces finished goods by using two production processes, the first and the second process. The first process is conducted by the factory 1 which is in the home country. The factory 1 manufactures intermediate goods, mq. The second process is assigned to the factory 2 which locates in the foreign country. The factory 2 composes final goods by using the intermediate goods.

The intermediate goods produced by the factory 1 are transported to the factory 2 by the transfer price, mp[2]. 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 can determines the supply quantity of the final goods at the market in order to maximize *the factory's* profit. On the other hand, the factory 1 decides the transfer price of the intermediate goods in order to maximize the *firm's* profits. The corporation tax rates of the home and the foreign country are represented by t and t^*, respectively.

2.2 Derivation of the profit function of the factory 1

[1] The basic framework is constructed according to Weber (1909), Puu (1998) and Ishikawa (2016). Firm's production system organized by internationally is clearly explained by Shi-Yang (1995).

[2] The transfer price is explained by Hirshleifer (1956).

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

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

where C (mq) is the cost function of the factory 1 and F_1 is fixed cost. The cost function C (mq) is derived on the basis of the following assumptions. The factory 1 uses two different kinds of materials m_1, m_2 to produce the intermediate goods. And the factory 1 needs lubricating oil m_3 to operate 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). Freight rates of the materials m_1, m_2 are denoted by t_m, and the rate of the oil m_3 is given by t_e. The intermediate goods are transported from the factory 1 to the factory 2 which locates at the market at point M_4, (x_4,y_4). 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 denoted by p_1, p_2, and p_3. Figure 1 illustrates the geographical relationships between the factory 1, the factory 2, the market and points of the three materials.

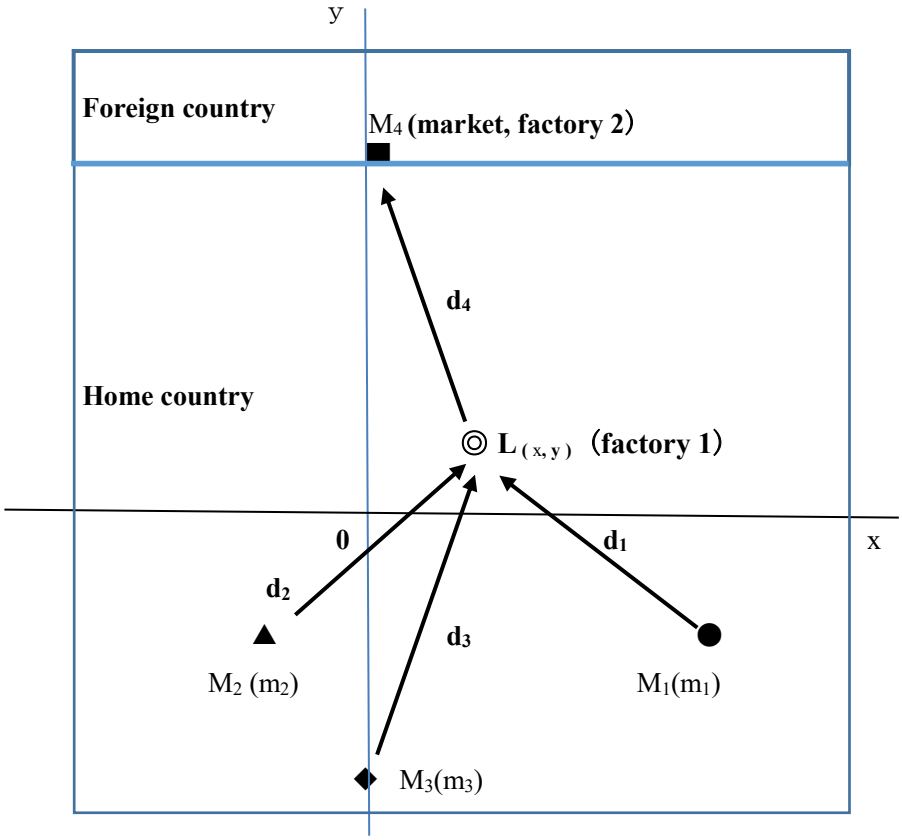


Figure 1 Location figure

The territory of the home country is shown by the square area and that of the foreign country is

rectangle area. The 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.

The production function of the factory1 is supposed as equation (2),

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

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 the factory1 are represented by d_1, d_2, d_3, respectively:

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

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

$$d_3 = (x^2 + (y + y_3)^2)^{0.5} \qquad (3c)$$

The distance between the factory1 and the factory 2 which locates at the market M_4 is given by d_4,

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

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:

$$P_1 = p_1 + t_m d_1 \qquad (4a)$$

$$P_2 = p_2 + t_m d_2 \qquad (4b)$$

$$P_3 = p_3 + t_e d_3 \qquad (4c)$$

And the price of the intermediate goods at location of the factory 2, DP, which is needed to calculate the revenue of the factory 1, is represented by equation (5),

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

Making use of the law of equi-marginal productivity, that is, the ratio between the productivities of the two intermediate goods 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):

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

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

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

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

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

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

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

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

2.3 Profit functions of the factory 2 and the manufacturing firm

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

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

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),

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

Suppose that the composing cost C (Q) is given by equation (4-11),

$$C(Q) = b\, Q(g + Q)^2/h \qquad (11)$$

where parameters b, g, h 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, the *mq* can be replaced by Q. The profit function is rewritten by equation (12),

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

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, the profit of the factory 2 is also represented as a function of the transfer price as equation (14),

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

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

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

2.3 Derivation of Location Prospective Area

2.3.1 Usefulness of chaotic phenomenon

Let us derive the optimal location (X, Y) of the factory1 and the transfer price by using equation (15). To derive transfer price and the location of the factory 1, the gradient dynamics is used (Puu, 1998, Ishikawa, 2009). This method is useful because if the solution could not be specified, the area in which the solution is included is indicated by a chaotic phenomenon.

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 the 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 iterated 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 can be 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 2. Figure 2 indicates that the optimal transfer price is approximately 442 and the optimal location site is hidden by a chaotic phenomenon[3]. Although the accurate location of the factory 1 is not identified by the appearance of the chaotic phenomenon, the chaotic phenomenon provides very an important information that the optimal location site is within the area where a chaotic phenomenon appears because phenomenon appears surrounding the optimal solution. If firm locates the factory 1 within the chaotic area, the firm's profit is not varied so much[4]. When the firm locates the factory 1 at point M_1, the profits is derived as 3307. The firm can obtain the almost same profits when the factory1 locates within the area where the chaotic phenomenon appears.

In this situation, if location of the factory 1 is fixed at point M_1, profits of the factory 1 and firm and production amount can be derived; they are shown at the upper row in Table 1. And if the freight rate of the intermediate goods is higher as 0.85, as shown by Figure 2B, the location prospective area appears around the market place. In this case the factory locates near the market place. And the location

[3]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.

[4] The difference of the two profits may be estimated less than 1 percent to the obtained profit.

of the factory 1 is fixed next to the market place, profit and transfer price of the factory 1 and profits and production amount of firm are derived and they are indicated in the lower row in Table 1.

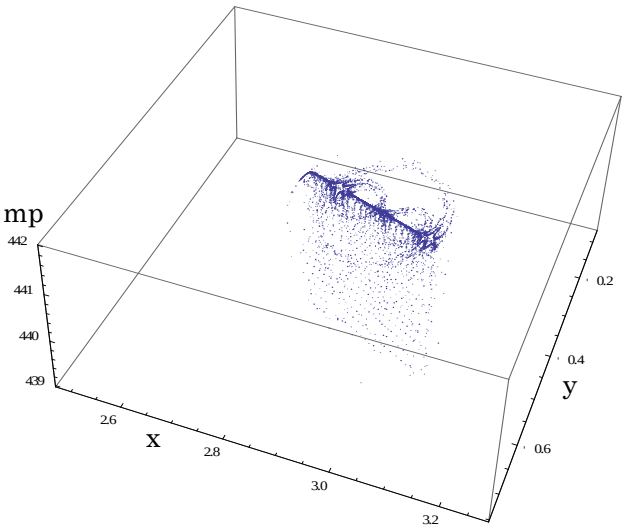


Figure2A Location prospective area of factory in low freight rate

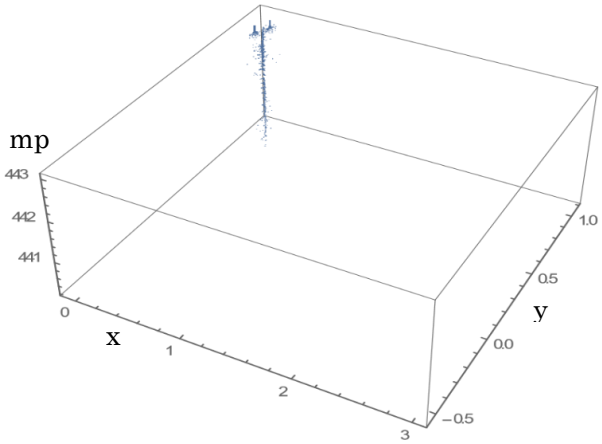


Figure2B Location prospective area of factory in high freight rate

Table1 Location, transfer price and profit of factory in different freight rates

freight rate	location	transfer price	amount	profit of firm	profit of factory1
t_g=0.225	around M_1	442	49.19	3307	2968
t_g=0.85	around M_4	443	48.97	3278	2948

2.3.2 Interpretation of location prospective area

The chaotic phenomenon can be interpreted as follow: If a firm decides the location of the factory 1 and transfer price of the intermediate goods in the sphere of the chaotic phenomenon, the firm's profits

are almost same because the optimal solution is contained in this sphere. It can be, therefore, considered that the spatial range of the phenomenon indicates *a location prospective area*, LPA for a possible factory's location. By setting a Location Prospective Area in large geographical space by using the chaotic phenomenon the firm can determine the searching area into a small range; they can reduce significantly the searching costs. Chaotic phenomenon may provide a firm with useful information in the case a firm does not have adequate information about several countries and many regions in a large space. Furthermore, the Location Prospective Area provides a firm with various location factors: When a firm decides the factory's location within the Location Prospective Area, a firm can consider the location issue in a broader perspective. A firm can incorporate many location factors such as education, culture, housing, safety, and welfare within the area into its decision-making. Considering of the locational effects of these location factors, a firm can find out the location of its factory that would be the best site for the firm's activity as a whole.

2.4 Construction of industrial park

2.4.1 Necessity of industrial park

As shown in the above analysis, when the freight rate of the intermediate goods is relatively high, the factory 1 locates near the market place, while, if the freight rate is relatively low, the factory locates near point M_1. Thus, it is suggested that in the period that infrastructure of the transportation is not adequate, industrial park tends to be constructed near market place; when the transportation infrastructure is adequate and logistics system is developed, location of industrial park is not limited to near market place, but it is built at various sites departing from the market place. In the derivation of the results, agglomeration economies are not incorporated into the framework of the analysis. If these economies would work in the firm's location decision-making, the location of the factory 1 is surely influenced.

Suppose that when the factory 1 is attracted to the market place, point M_4, in the foreign country to co-exist with the factory 2, scale economies generated at the market place decrease the production costs of the factories. Scale economies would exercise its locational power for the factory 1 to move to the market place. If the agglomeration of the two factories is realized at the market place in the foreign country, the home country loses the tax revenue from the factory 1. In this context, the importance to build industrial park would be realized by the home country. It is said that the government of the home country establishes an industrial park, which provides the factories with external economies and useful business functions, in order to retain the factory 1 in the home country, or to regain the factory from the foreign country into its territory[5].

[5] Bredo (1960) analyzes industrial estates as a tool for industrialization. This analysis is instructive to examining the role of the industrial parks for development of regional economy.

2.4.2 Combination of business types within an industrial park

According to the above analysis, location of industrial park is not confined to a specific site, but it is selected considering the location prospective areas (hereafter LPA) of firms. And industrial park selects the factories which possesses the resemble characteristics each other in terms of the nature of the goods and production facilities. Hence, when a developer establishes an industrial park in a region, the developer is likely to induce factories of which location prospective areas make overlapping area and establishes the park within the overlapping area. If the factories' LPAs, therefore, are not overlapped, these factories are not co-existed in the same industrial park. Figure 3A and 3B describe these situations. Two chaotic phenomena in Figure 3A are shown based on the analysis in previous section. In this figure, two factories' LPAs do not make an overlapping area, then, these two factories may not locate in the same industrial park. While, Figure 3B shows that two chaotic phenomena for the two factories are overlapped near point M_1. The possibility would be high that these two factories are induced in the same industrial park established near M_1.

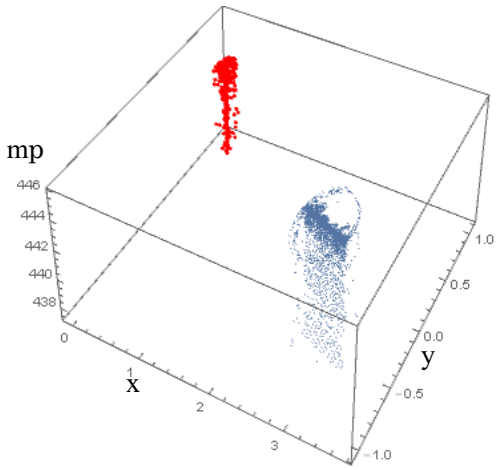


Figure 3A Two LPAs departing each other

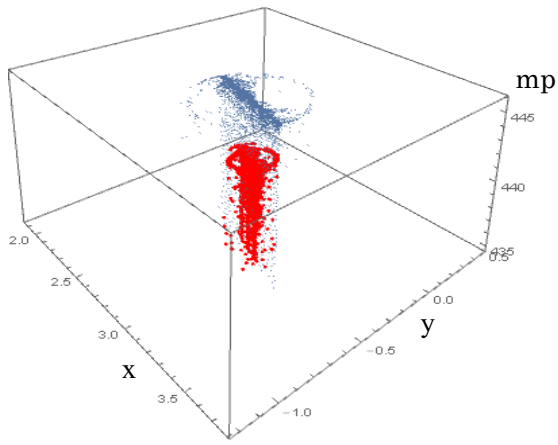


Figure 3B Overlapping of two LPAs

3 Relationships between external economies and composition of industrial park

3.1 Business types combined in industrial park

In order to examine the effects on industrial park of difference of business types in an industrial park, suppose three kinds of factories which belong to different business types, a, b and c. Although they are in the same spatial and production situation shown in section 2, they are different in terms of production of intermediate goods: factory 1_a which belongs to business type a is assumed that the production efficiency A_a is 1 and the freight rate of the intermediate goods t_{ga} is 0.225; and factory 1_b of business type b is that A_b=1 and s t_{gb} is 0.7728; and in the case of factory 1_c of business type c is that A_c=1.05 and t_{gc} is 825.

On this assumption, let us derive chaotic phenomena of two factories, 1_a and 1_b. Figure 4 shows two

chaotic phenomena of the two factories. LPA of factory l_b is long from point M_1 to the market place, point M_4. These LPAs makes overlapping area near point M_1. And then, chaotic phenomena of the two factories, l_b and l_c. are shown in Figure 5. In this case, LPAs of the two factories, l_b and l_c are overlapped near the market place. It is said, therebefore, that industrial park established near point M_1 is composed by the factories, l_a and l_b, while, industrial park established near market place is composed by the factories, l_b and l_c. Since the factory l_b has a long LPA, this factory has a possibility to locate either industrial park.

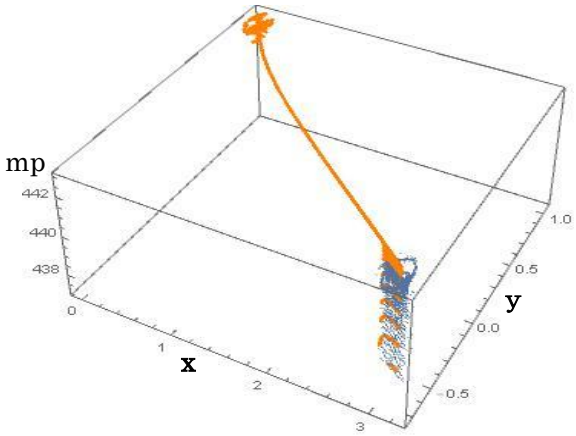


Figure 4 Overlapping of LPAs of two factories near point M_1

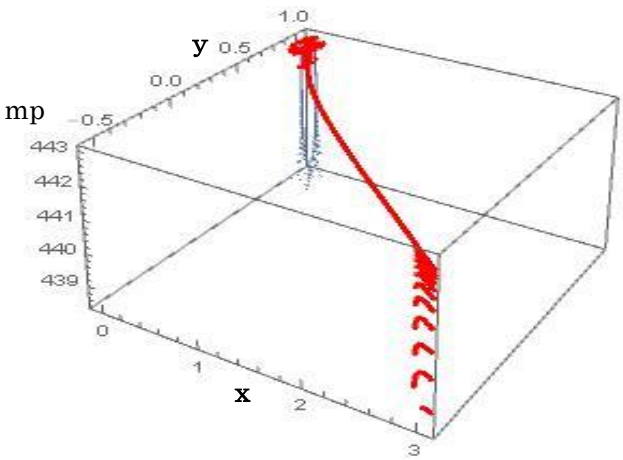


Figure 5 Overlapping of LPAs of two factories near the market place

3.2 Decrease of production costs of factories by enjoying external economies

It is needless to say that the number of factories in an industrial park is not limited to two. In this subsection, introducing the concept of external economies into the analysis, the number of factories in industrial park is analyzed. To this end, new assumptions are added in the analysis.

(1) The business types of factories are classified to three types, *a, b,* and *c*; and based on the result derived in the previous section, if industrial park is constructed near point M_1, the combination of business types is confined into the combination of *a* and *b*: And when

industrial park is established near the market place, the combination is *b* and *c*.

(2) The number of factories (N_i, i=a, b, c) of each business type in industrial park is determined by the developer of industrial park in order to maximize profit of individual firms.

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

(4) Industrial park provides two different kinds of external economies: One of external economies (EEv) reduce the variable cost of individual factories, and the extent to which the economies reduce the cost is a function of the *sum* of the number of workers employed by each factory in the park. Equation (18) shows the function of externality of (EEv).

$$EE_v = -h(0.05(TL))^2 + j(0.05(TL)) - k \qquad (18)$$

where TL is the number of employees in the park, and *h, j,* and *k* are parameters. Wage rate is a function of the number of workers who are employed by *each business type*; wage rate of each business type is indicated by equation (19)

$$w_i = g(N_iL_i)^{\Phi} \qquad (19)$$
$$i=a,b,c$$

where N_iL_i is the number of workers employed by all factories of business type *i* (i=a, b, and c), g and Φ are parameters.

(5) Another externality economies (EE_F) reduces the fixed cost of the factories, 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),

$$EE_F = -\alpha(TQ_j)^2 + \beta(TQ_j) - D \qquad (20)$$
$$j = M_1, M_4$$
$$TQ_{M1} = N_a * mq_a + N_b * mq_b, \; TQ_{M4} = N_b * mq_b + N_c * mq_c$$

where α, β, and D are parameters. When industrial park is constructed near point M_1, TQ is shown by TQ_{M1}, while, the park is constructed near the market place, TQ is given by TQ_{M4}. In this section the fixed cost are supposed that the fixed cost contains not only the cost 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, CL, is assumed to be zero for simplicity of the analysis.

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

3.3 Derivation of the number of factories in industrial park

Using the analysis in previous section, profit of individual firms is obtained by using equation (21),

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

Let us suppose that using the results in the previous section, production amount and transfer price of the factory 1_a are that mq_a＝49.19, mp_a=442, and those of the factory1_c are mq_c＝49.09, mp_c442.5: And when 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 market place, they are that mq_b＝48.97, mp_b=443.Based on the supposition, let us analyze the production composition of each industrial park.

As explained in the previous subsection, developer of industrial park decides the number of factories of each business type in order to maximize profit of individual firms. The developer which establishes an industrial park near point M_1 determines the numbers of the factories,1_a and 1_b. And each kind of firm decides the number of workers to maximize its profit. Thus, the number of each factory and the number of workers of each factory in the industrial park 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 factories, 1_b and l_c and the numbers of workers of the factories in the industrial park near market are obtained.

Now, the parameters that determine the two kinds of external economies generated in the industrial parks are given as shown in Table 2. Let us derive the number of each factory and the number of workers of each factory in the industrial park near point M_1.

Table 2 Parameters' values that define external economies

h	j	k	α	β	D	g	Φ
0.01	4	20	0.0008	0.71	52.57	0.6	0.15

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 industrial park near point M_1. The production composition is indicated in Table 3A. Similarly, the production composition of the park near the market place is indicated in Table 3B. The comparison of production compositions in the industrial parks that are shown in Table 3A and 3B indicates that even if the parks are the same size and quality, the production composition and profits generated in the parks are different. Their changes due to the difference of production characteristics of the factories which co-exist in an industrial park.

Table 3 A The production composition of the industrial park near point M_1

	number of factories	number of workers	production amount	profit
factory1_a	—	85.23	49.26	3872
factory1_b	—	***121.37***	***49.09***	***3843***
business type *a*	5.29	450.4	260.1	20449
business type b	*3.74*	***454.3***	***183.6***	***14385***
industrial park	9.02	904.7	443.7	*34834*

Table 3 B The production composition of the industrial park near market place

	number of factories	number of workers	production amount	profit
factory1_b	—	***119.52***	***48.97***	***3862***
factory1_c	—	95.2	49.09	3872
business type b	***3.79***	***504.7***	***179.2***	***14653***
business type *c*	5.30	452.9	264.6	20499
industrial park	9.05	957.7	443.8	*35161*

Especially, it is interesting to compare the profits of the factory 1_b which are indifference in the factory's location between point M_1 and the market place if the factory does not enter into industrial park. The profits and production composition of the business type *b* are indicated by bold figures in Table 3A and 4B. Since the factories of the business type *b* are able to obtain the higher profit by entry into the industrial park near the market place than the park near point M_1, the factories of business

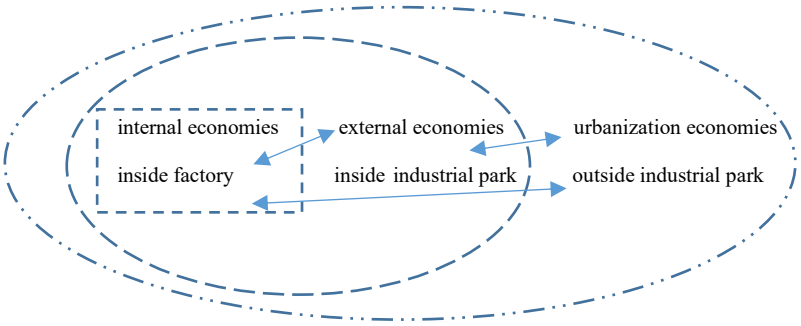
type *b* locate in the park near the market place. The profit difference of the factory 1_b is yielded by the difference of the production composition formed in the two industrial parks: As indicated in the provirus subsection, when the factory1_b does not join into industrial park and the factory locates at point M_1, the profit of the factory 1_b is 2947.9, while, the factory 1_b locates at the market place, the profit is 2948.1. The profit difference is only 0.2. If the factory 1_b locates in the industrial park at point M_1, profit of the factory is increased by 895, while the factory 1_b locates in the park near the market place, profit is increased by 914. These profit increases are generated by the factories' entering into the industrial park. And the factory's profit difference of 19 in between the two industrial parks is yielded by the differences of the production compositions in the two industrial parks.

4 Effects of urbanization economies on production composition in industrial park

4.1 Incorporation of urbanization economies into the analysis of industrial park

The merit of industrial park is to provide factories with external economies suitable to the factories. These economies are usually generated by the production infrastructure equipped with the park. It is difficult, however, for an industrial park to serve the factories with so-called urbanization economies that are usually provided by cities in a region. Urbanization economies are generated by various kinds of public and private facilities and functions which are usually located in cities with a certain population size. Thus, some industrial parks have a tendency to be established within urban areas of large and medium cities. Especially, when industrial park contains the factories which need to use several sorts of labors to produce goods and some cumbersome management supports, the park is likely to locate near large city in order to reduce the overhead costs. Figure 6 describes the relations between internal and external economies. These economies reduce factories' production costs by interlocking each other inside and outside an industrial park.

Figure 6 Relations between internal and external economies



4.2Assumptions of the analysis

Let us analyze the relationships between urbanization economies and the production composition of industrial park. Some assumptions are changed from the previous analysis. Industrial park is only

established near point M_1. Thus, the business types are confined to *a* and *b* in the industrial park. Production amount and transfer price of the factory 1_a are that mq_a=49.19, mp_a=442. While, the production efficiency, A_b, of the factory 1_b is changed to be 0.5, and thus, production amount and transfer price of the factory 1_b are changed as that mq_b=48.28 , mp_b=445.8.

City's size is classified into three classes, large, medium, and small: Large city provides high urbanization economies, but industrial park in this city is relatively small due to high land price. Economies of small city are not so high as those of large city, but the industrial park in the small city is relatively large. Medium city has intermediate features in between the large and the small city.

4.2Effects of urbanization economies on production composition in industrial park

It is assumed in this subsection that the two kinds of external economies, which are introduced in the previous sector, are provided in industrial park in the three different sized cities: The external economies, EEv, work to reduce variable cost of factories and these economies are varied by the number of workers in the park. While, the external economies, EE_F work to reduce fixed cost of factories and these economies are changed by the production amount in the park. The efficiencies of these two external economies in each city are indicated by the parameters' values shown in Table 4.

Table 4 Parameters' values that indicate external economies in industrial park

city size	h	j	k	α	β	D	g	Φ
large	0.0277	2.094	0.1	0.00156	1.46	105.14	1	0.2
medium	0.02	2	10	0.0007	0.73	54.57	0.75	0.15
small	0.0135	1.443	8.57	0.00033	0.3842	27.67	0.6	0.4

Based on the parameters' values shown in Table 4, the two kinds of external economies provided in industrial park in each city are illustrated in Figure 7A,7B and Figure 8A, 8B. First, Figure 7A shows the relationships between the external economies, EEv, and the number of workers, L, in industrial park for the large city and the medium city. The large city provides higher externalities, which is shown by dotted line, than those of the medium city in small number of workers, the economies become lower than those of the medium city in a range of small number of workers due to small industrial park. Figure 7B shows the relationships between the external economies EE_F and the production amount, TQ, in industrial parks at the large city and the medium city. The relationships are similar to the case of EEv. The large city provides higher externalities, which is shown by dotted line, than those of the medium city, but the economies, EE_F, become to zero at the less production amount than that of the medium city due to small size of the industrial park.

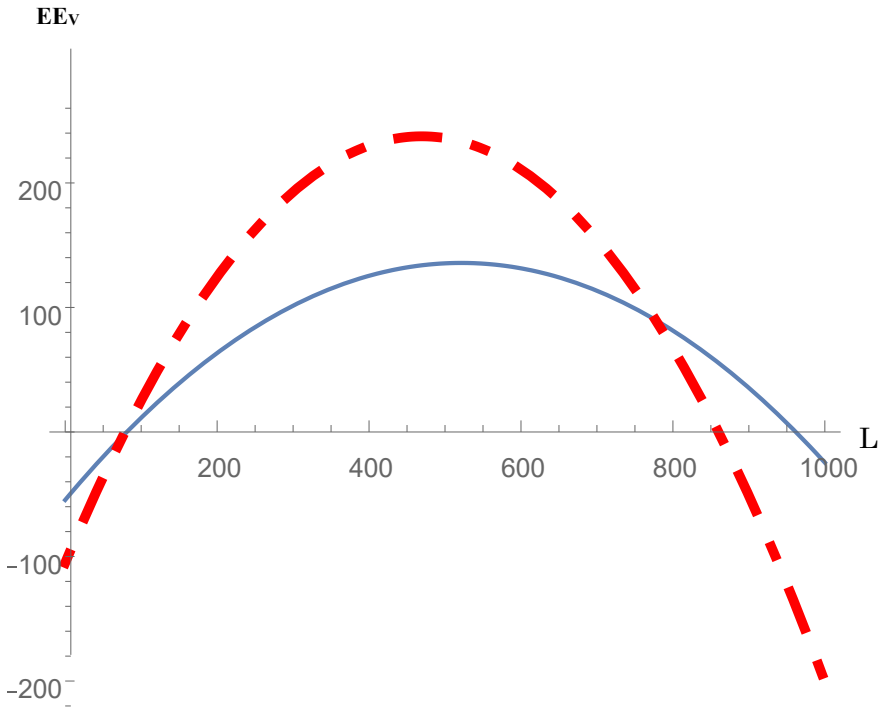


Figure7A External economies generated by the number of workers in medium city and large city

Note: dotted line indicates the relation between EEv and number of workers in large city

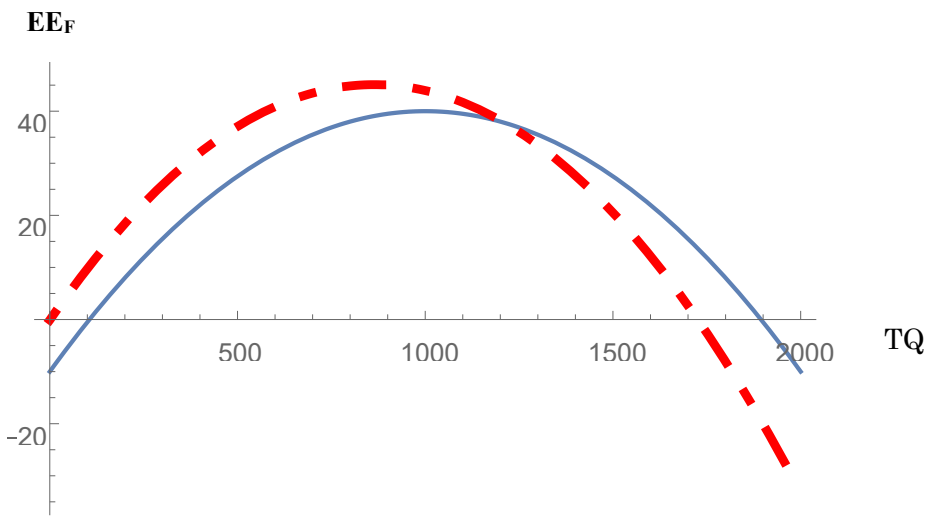


Figure7B External economies generated by the production quantities in medium and large city

Note: dotted line indicates the relation between EEF and production amount in large city

Figure 8A shows the relationships between the external economies EEv and the number of workers、L, in industrial parks at the Medium city and the small city. The small city provides lower externalities, which is shown by dotted line, than those of the medium city in a range of small number of workers, the economies become higher than those of the medium city in a range of large number of workers

due to large size of the industrial park. Figure 8B shows the relationships between the external economies EE_F and the production amount, TQ, in industrial parks at the medium city and the small city. The relationships are similar to the case of EEv. The small city provides lower the externalities, which is shown by dotted line, than those of the medium city, but the economies become to zero at the larger production amount than that of the medium city due to large industrial park.

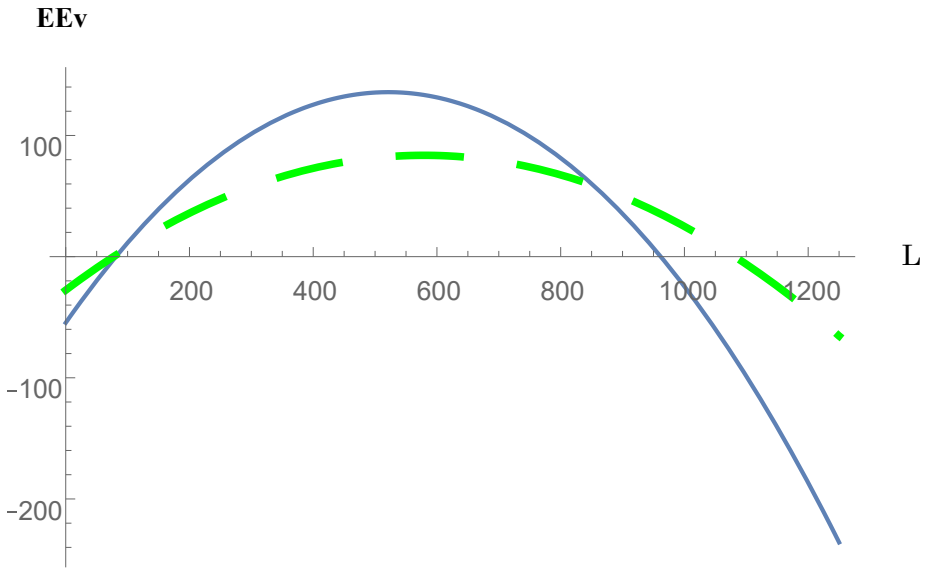


Figure 8A External economies generated by the production quantities in medium and small city

Note: dotted line indicates the relation between EEv and number of workers in small city

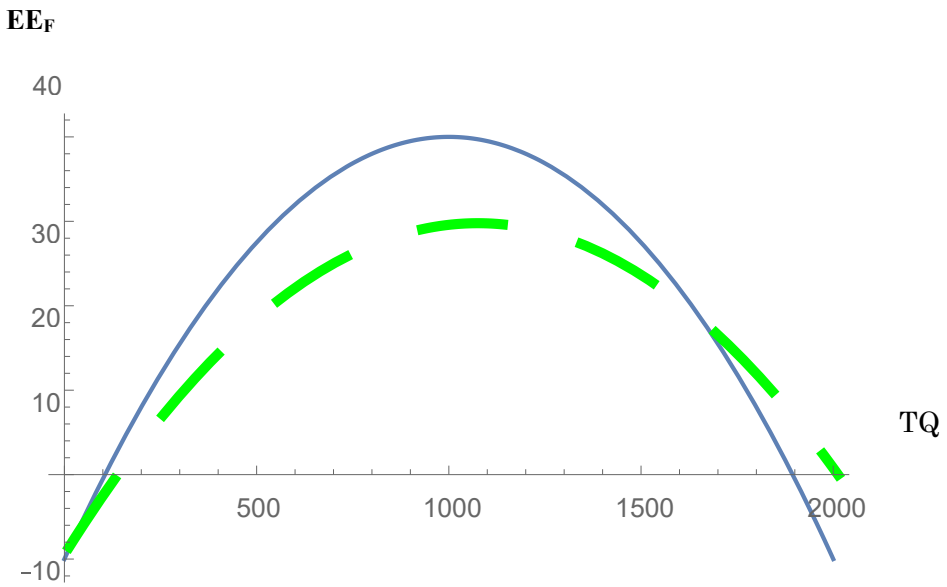


Figure 8B External economies generated by the production quantities in medium and small city

Note: dotted line indicates the relation between EE_F and production amount in small city

Lastly, Figure 9 shows the relationships between the number of workers employed, Li, (i=a, b), in each

business type and its wage rate, w, to the three different sized cities.

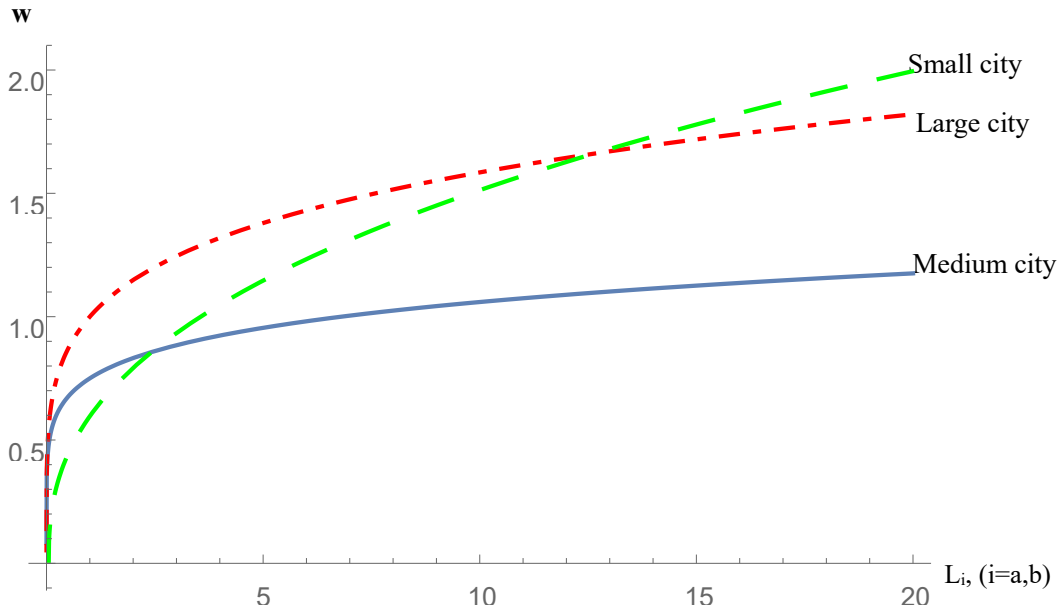


Figure 9 Relationship between wage rates and the number of workers of each business type in different city sizes

These relationships between wage rate and the numbers of workers in each sized city are indicated by the parameters g and Φ in Table 4. The relationship wage rate and the numbers of workers in small city can be considered as the following logic: The wage rate of small city is the lowest in the number of workers is small, but it becomes higher when the workers increase in the industrial park compared with those of large and medium cities. Because the transportation infrastructure is not adequate in small city, the commuting area of workers is so small that the supply capacity of workers is limited, thus, wage rate becomes higher rapidly as the number of workers increases.

Let us derive the production compositions and profits of individual factories and industrial park to the three different sized cities. Table 5 shows the results of the calculations of equitation system (22a,b,c,d) used in the previous sections.

Table 5 Production construction and profit of the industrial parks in the different sized cities

	number of	number of	workers of	workers	profit of	profit of	total profit of
city size	factories 1a	factories 1b	factories 1a	factories 1b	factory 1a	factory 1b	in the park
large	6.71	2.89	662	469.2	3854.6	3830.3	36907.8
medium	7.23	3.44	958.2	521.4	3862.7	3833.9	41088.9
small	8.38	3.47	741.6	579.4	3793.7	3818.5	45011.8

It is individual firms that have the largest power to determine the production composition of industrial park. As shown in Table 5, profits of individual factories are maximized when they locate in

the industrial park established in the medium city. Hence, it is considered under the assumptions laid in the analysis that the possibility of industrial park constructing at the medium city is high. While, from the view point of the developer of industrial park, which pay attention to the total profits generated in the park, the developer wants to locate the industrial park at the small city. Under the assumptions in this section, the large city is not selected from the viewpoint of profit level. Considering the number of workers in the park, the industrial park at the medium city provides people in a region with largest number of workplaces. Medium city may be favored as the site of industrial park.

4.3 Effects on industrial park of the government intervention to improve infrastructure

When industrial park is established at a small city, wage rate is assumed to be raised rapidly as the number of workers increases. This is because that transport infrastructure is not adequate within urban area of a small city and the commuting area of workers is narrow, thus, the wage rate is likely to rise quickly. Based on this logic, the parameter is assumed to be 0.4. If the government invests to improve the infrastructure, the rise of wage rate is curbed, and the wage rate would become lower.

Assuming that the parameter Φ is lowered to 0.3 at the industrial park in a small city, the working levels of the two kinds of external economies in the park are the same as shown by the third row in Table 5, this subsection analyzes the effects of the government investment to improvement of the transportation infrastructure on the industrial park established in small city. The production composition and profits of the factories in the industrial park in a small city are derived by the same way used in the previous section. Table 6 shows the production composition and profits in the industrial park after the government invests to transport infrastructure surrounding the park.

Table 6 Production construction and profits of the industrial park in better infrastructure

	number of	number of	workers of	workers of	profit of	profit of	total profit of
city size	factories 1a	factories1b	factories1a	factories 1b	factory 1a	factory 1b	the park
small	8.85	2.99	711.6	213.2	3830.5	3813.7	45277.1

Although the number of the factories and total production amounts in the industrial park are not varied, the profit of the factories I_a is increased and the profit of the industrial park increases to 45277.1 which is higher than that earned by the industrial park by 265 before the government's investment. But, profit of the factory I_b decreases by 4.8 after the government's investment. The government's investment to improve the infrastructure does not make every economic agent's situation better.

5 Concluding remarks

In the period of the globalized economy, the production processes of manufacturing firms are fragmented into small blocs, and they are scattered over the world. And many governments try to

induce these fragmented processes into their territory to vitalize regional economy. In this context, industrial park is attractive to both the manufacturing firms and the governments because an industrial park provides factories with appropriate external economies and necessary production facilities and attract many factories to a few specific sites in regions.

The primary results derived from the analysis are summaries as follows: The location of industrial park is not limited straight away to a specific point, but it is settled at point within the overlapping area of the location prospective area of factories. External economies generated in industrial park influence the individual firms' profits and the combination of business types, production composition of industrial park. In addition, urbanization economies provided by cities with different size affect industrial park in different ways: It is said that the medium city may be favored by the manufacturing firms and regional governments, while small city tends to be selected by the developer of industrial park. Lastly, investment aiming to reduce the wage rates of workers does not always increase every firm's profit, but profits of some kinds of firms in the park are decreased. The effect of change of external condition on the profits of firms in industrial park is complicated because the production composition in the park is varied responding to the change outside the park.

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