

Zhang, Yang; Sasaki, Komei

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Edge City Formation and the Resulting Vacated Business District

Yang Zhang and Komei Sasaki

(Graduate School of Information Sciences, Tohoku University)

Abstract:

The effects of edge city formation on the structure of an existing core city are investigated. Focus is put on the phenomenon of “vacated business district” in the core city. It is hypothesized that some area of land in an existing business district becomes vacant due to edge city formation because of the transformation and/or adjustment costs of land. Equilibrium configuration in a metropolitan area is investigated, and various comparative static analysis is performed by numerical simulation method.

Keywords: Edge city, Core city, Land transformation cost, Vacated business district, Social benefit

Proposed running head: Edge city and vacated district

JEL classification: R12, R13, R14.

Mailing address: Yang Zhang

Graduate School of Information Sciences,
Tohoku University,
SKK Building, Katahira 2
Aoba-ku, Sendai 980.
Japan

Fax: +81-22-263-9858

e-mail: zhang@skk.is.tohoku.ac.jp
sasaki@skk.is.tohoku.ac.jp

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1. Introduction

Formation of an edge city is distinguished from the emergence of a conventional subcenter or suburbanization of activities. An edge city is formed by a large scale developer's (or city government's) strategic development of a suburban area or the outside of an existing core city, while subcenter formation or suburbanization are the result of economic reactions to higher land rents and wage rates and/or traffic congestion in the central area or a city. Of course, in most cases of conventional subcenter formation, the local government (as with development of an edge city) undertakes the infrastructure investment to develop the area around the subcenter locations in the initial stage. However, in the case of edge city formation, a developer needs to predict the future size of the business district and residential area by taking into consideration the economic behavior of firms and households. Thus, subcenter formation and edge city formation share some common features but what definitely differs between the two phenomena is that a developer will determine the central location of an edge city in a strategic way.

Since Joal Garreau [1991] gave a detailed account of actual edge cities in the United States, edge city formation has attracted the attention of urban economists. To our best knowledge, Henderson and Mitra [1996] provided the first real modelling of edge city formation. In that model, the location of the business district in an edge city, and the capacity of that district in terms of capital stock were determined by a developer so as to maximize his profits from production in the new business district. It is assumed that production activities use no land, and thus a business district is represented as a "point", while residence requires land which is rented from absentee landlords at the prevailing rent. A central point of Henderson and Mitra's paper is the competition between the existing CBD and a new business district, which greatly affects the decision of the location and capacity of a new business district.

In Fujita et al. [1997] also, firms use no land, but the behavior of households is explicitly formulated and the total differential land rent (TDR) in an edge city is included among the developer's profit (although only where the demand for labor

at a CBD is infinitely elastic). A remarkable presumption in the model of Fujita et al. [1997] is that when some area in an existing core city is used for a new edge city, a developer of an edge city rents the land in that area from absentee landlords, not at the agricultural rent but at the prevailing market rent in the core city. This presumption is important to represent the dynamic aspect that an edge city is newly developed, where a monocentric core city equilibrium has been established.

Whether the new business district is generated by a subcenter or an edge city, the firms operating at the CBD in a core city face competition with firms located in the new business district. This competition arises through the markets for labor and land. The households which have commuted a long distance to a CBD could increase their utility level by changing their workplaces to the new business district to shorten their commuting distance. This will tend to raise the wage rate at a CBD, and to increase the land rent in the existing residential area. As a result of competition between the two centers, i.e., a CBD and a new center in an edge city, some firms and stores will withdraw from a CBD, and thus the CBD area shrinks. This phenomenon is referred to as the “vacated business district” phenomenon in Japan. The papers of Henderson and Mitra [1996] and Fujita et al. [1997] assume that no land is used for production activities, and that the previous CBD-workers’ residences can be used, as they are, for new center-workers’ residences. Therefore, in their models, there is no possibility that land in some area of the existing core city becomes vacant as a result of a shrinkage in production levels in the CBD. In reality, however, vacant land, vacant offices, and unused building emerge after firms and stores have withdrawn from that area and they are left unoccupied for a long time: the so-called “shutter street” phenomenon is observed in many cities in Japan, and such dereliction in the central area of a core city exerts a negative influence on business activities to generate farther economic decline in that area¹.

The aim of this paper is to analyze and assess the impact of edge city formation on the structure of a core city, focusing on the vacated business district. To achieve this, unlike in Henderson and Mitra [1996] and Fujita et al. [1997], it is essential to examine land use pattern in business district.

The basic model is presented in section 2. Section 3 discusses the equilibrium urban configuration where an edge city is formed. The comparative static analysis is performed by numerical simulation in section 4. Section 5 states some concluding remarks.

2. The model

2.1 A monocentric core city

A linear city of unit width is assumed, as shown in Figure 1. A CBD is located at the left edge, where firms of office industry operate with only labor input. In Figure 1, the area between the CBD and T_0 is used for commerce activity, which supplies “composite goods” to city residents using only land input. The area between T_0 and B is used for residence, from where every household commutes to a CBD. All of the land between CBD and B is provided by absentee landlords, who rent the land at each location to an agent offering the highest bid-rent. The behavior of each agent is explained.

Office firm:

The services produced by office firms at a CBD is supplied to a national market, and its price, P , is given at the national market. On the assumption that each office firm employs a fixed amount of labor force, n , the production technology of a firm is represented as

$$Y_c = (f_c)^\alpha n \quad (0 < \alpha < 1) \quad (1)$$

where Y_c is output, f_c the number of office firms operating in a CBD, and $(f_c)^\alpha$ represents the agglomeration economy. Letting W_c denote the wage rate, the profit of each firm is expressed as

$$\pi_Y = P(f_c)^\alpha n - W_c n \quad (2)$$

In equilibrium, to ensure zero profit to each firm, the wage rate is assumed to be adjusted so that

$$P(f_c)^\alpha = W_c \quad (3)$$

Commerce firm:

Each commerce firm employs a unit of land, and produces composite goods subject to the following production technology

$$Q_c = (N_c)^\beta \quad (0 < \beta < 1) \quad (4)$$

in which N_c is total population in a core city and the term $(N_c)^\beta$ represents the

urbanization economy. Each commerce firm is assumed to make a certain number of trips during a unit period to the CBD to collect information on business and to communicate with other firms, and the trip cost is assumed to be proportional to the distance to the CBD. The profits of each commerce firm are thus represented as follows.

$$\pi_Q = P_c(N_c)^\beta - k_f t - r(t) \quad (5)$$

where r is the land rent at location t , and k_f the trip cost per unit distance. The commerce sector is competitive so that overall profit is zero in equilibrium, through new entrance and exit of firms. In equilibrium, the bid-rent of a commerce firm for land at t is

$$r_c^b(t) = P_c(N_c)^\beta - k_f t \quad (6)$$

Household:

Each household supplies a unit labor to the office industry, demands a unit land as residence, and the utility function of a household is assumed to be represented in the form of

$$U = Z^\theta \quad 0 < \theta < 1 \quad (7)$$

where Z represents the composite goods purchased from the commerce sector. The budget constraint of a household residing at location t is represented as follows.

$$W_c = P_c Z + r(t) + k_c(t - T_0) \quad (8)$$

where the last term on the RHS is commuting cost. We assume a specific, but not unrealistic fare system of commuting transportation: that is, the fare for public transportation from a particular location in the residential area into any part of the business district is the same, so that the commuting cost from location t to the CBD is the same as that from t to the outer boundary of the business district, T_0 ². By this assumption, it is ensured that the purchase cost of composite goods is the same, no matter at which store a resident buys composite goods, given that he/she buys it during the commuting trip. In this model, an open city setting is assumed, such that the utility level attained by each resident is given, whereby the consumption of Z is given from (7). In those circumstances, the bid-rent for residence at location t is

$$r_c^h(t) = W_c - P_c Z - k_c(t - T_0) \quad (9)$$

where k_c is the commuting cost per unit distance. As for the slopes of r_c^b and r_c^h , it

is assumed that $k_f > k_c$, so as to ensure that the business district occupies the inner part of a city.

An equilibrium configuration of this monocentric city is specified by equation (3) and the following equations.

$$N_c = n \cdot f_c \quad (10)$$

$$(N_c)^\beta T_0 = N_c Z \quad (11)$$

$$P_c (N_c)^\beta - k_f T_0 = W_c - P_c Z \quad (12)$$

$$W_c - P_c Z - k_c (B - T_0) = 0 \quad (13)$$

$$B - T_0 = N_c \quad (14)$$

Equations (3) and (10) represent equilibrium in the labor market, and Equation (11) equilibrium of the composite goods market. Equation (12) implies that the bid-rent of a commerce firm and residence is equal at the boundary. Equation (13) states that the bid-rent at the urban fringe is equal to the opportunity cost of land (which is assumed to be zero). Equation (14) expresses the accommodation condition of the population. This monocentric city system has six endogenous variables: that is, W_c, f_c, N_c, P_c, T_0 and B .

2.2 Formation of an edge city

Suppose a large-scale land developer plans to construct an edge city where the monocentric equilibrium configuration described above has been attained. A developer decides on the location of the center, E of the edge city. Once the location of E is determined, office firms will be newly located there: and around E new commerce districts will be formed, around which residential districts will be newly formed. Residents, office and commerce firms are perfectly mobile and, consequently, in equilibrium, the utility level of residents working at the new center is the same as that of workers at the existing CBD (both are equal to the given level of utility), and the profits of firms are the same (equal to zero) whether they operate in the core city or in a new edge city. The number of office and commerce firms operating in the edge city, population size, and the total land area of the edge city are determined so as to ensure a new equilibrium configuration of

a metropolitan area consisting of the old core city and the new edge city. The developer rents all the land in the edge city from absentee landlords to rent to each agent. In doing so, the developer pays the opportunity cost for the land outside of B , and the rent prevailing in the monocentric equilibrium for the land inside of B (since, otherwise, absentee landlords would not have agreed to rent the land to the developer).

Unlike Henderson and Mitra [1996] and Fujita et al. [1997], we assume that the developer of an edge city does not own firms, and that his profits come only from net rental revenue of land. In real urban development, in some cases developers themselves are engaged in production activities, but in some cases they only invest infrastructure capital in order to induce firms and households to locate in the edge city. The infrastructure cost depends on the area of the new city. A developer will determine the location E so as to maximize the profits, defined as the difference between net rental revenue and infrastructure cost.

The production function of an office firm operating at a new center is not the same as that of a CBD firm. This is because firms at the edge city center must make trips (for collecting information and undertaking face-to-face communication with customers and other firms) to the CBD where a “trading floor” has existed historically. For this trip to the CBD, the production efficiency of a firm at E is lower than that of the CBD, and the efficiency-decay rate increases with the distance to the CBD. That is, a production function of a firm at the location E is

$$Y_e = (f_e)^\alpha n \exp^{-\delta E} \quad (15)$$

where f_e is the number of office firms operating at E , and δ is the rate of the efficiency decline per unit distance. Letting the wage rate at E be W_e , the equilibrium condition in the labor market is

$$P(f_e)^\alpha \exp^{-\delta E} = W_e \quad (16)$$

The size of the business district in the edge city depends on how many commerce firms will be located on both sides of the new center, E . Commerce firms in the edge city are required to make a certain number of trips to E for information collection and communication. The bid-rent of a commerce firm in an edge city is

$$r_e^b(t) = p_e (N_e)^\beta - k_f |t - E| \quad (17)$$

in which N_e is the population in the edge city. The price of Z in the edge city, P_e , generally differs from P_c . In (16) or (17) the agglomeration economy works only locally, in that its degree depends only on population size in the edge city.

Two residential areas are formed outside the commerce district, and the workers residing there commute to the new center, E . Likewise, in the core city, transportation cost incurred by residents in the edge city also depends on the distance to the boundary between the residential and commerce districts. Thus, the bid-rent of a household residing at t in the edge city is

$$r_e^h(t) = W_e - P_e Z - k_c (\min\{|t - EL|, |t - ER|\}) \quad (18)$$

where EL and ER are the boundary locations of the commerce district in the edge city of the left-hand and right-hand sides, respectively.

A developer is supposed to have perfect knowledge of an equilibrium configuration of a metropolitan area, consisting of an existing core city and a new edge city, which is determined by a specific location of E as shown in Figure 2. A developer compares the performance of equilibrium configurations for various locations of E , and chooses an optimal location to maximize profits. The profits from edge city formation for a developer are defined as

$$\pi_D = \int_D^H r(t)dt - \int_D^B r_m(t)dt - F(H - B) \quad (19)$$

in which $r_m(t)$ is the market rent which prevailed under the monocentric city equilibrium. The last term on the RHS in (19) is the infrastructure investment cost, which is an increasing function of the total area of the edge city, $(H - B)$, and it is assumed that $F' > 0$ and $F'' > 0$.

3. Equilibrium for two cities

3.1 Where transformation of land is free

Edge city formation affects the structure of the core city and generates a new equilibrium. If the land previously used for the core city can be converted for new land use without additional cost, then an equilibrium configuration of two cities

will emerge, as shown in Figure 2. Hereafter, it is assumed that the location E , lies at the center of the commerce district in an edge city, such that $E - EL = ER - E = s$. An equilibrium for two cities is specified by equations (3), (10), (16), along with the following equation:

$$(N_c)^\beta T_1 = N_c Z \quad (20)$$

$$P_c(N_c)^\beta - k_f T_1 = W_c - P_c Z \quad (21)$$

$$D - T_1 = N_c \quad (22)$$

$$W_c - P_c Z - k_c(D - T_1) = W_e - P_e Z - k_c(EL - D) \quad (23)$$

$$N_e = n \cdot f_e \quad (24)$$

$$E - EL = s \quad (25)$$

$$2s(N_e)^\beta = N_e Z \quad (26)$$

$$P_e(N_e)^\beta - k_f s = W_e - P_e Z \quad (27)$$

$$H - D - 2s = N_e \quad (28)$$

$$W_e - P_e Z - k_c(H - E - s) = 0 \quad (29)$$

Equations (20) and (26) are equilibrium conditions in composite goods markets in the core and edge cities, respectively. Equations (22) and (28) are conditions for accommodating the population in the two cities. Equation (24) represents the balance of demand and supply of labor in the edge city. Each of equations (21), (23), (25), (27) and (29) determines the respective boundary. In Figure 2, the number of commerce firms in the core city decreases by $(T_0 - T_1)$ (since each commerce firm uses a unit of land) due to edge city formation. The population of core city also decreases by $(B - T_0) - (D - T_1)$, and the number of office firms at the CBD decreases accordingly. Because of this decline in economic activity level in the core city, the land rent will be lowered in most parts between the CBD and the new fringe of the core city, D .

3.2 Where the business district in the core city is vacated

In the previous case, it was assumed that the existing business district in the core city can be freely converted to residences. For instance, the land between T_1 and T_0 in Figure 2 has been used for the business district in the monocentric core city, and was converted to residence in the new two-city equilibrium. In reality, however, it is costly to convert a noisy and dusty business district into a quiet, and clean residential district; and it takes time for landowners to accept the change in land use (from business to residential) since the rental revenue will be substantially decreased. If no extra cost and time are required for adjustment, the vacant lot phenomenon would never emerge. Therefore, the cost for conversion of a business district into a residential district needs to be explicitly considered in order to model the vacant lot phenomenon in the existing business district. In this situation, it is assumed that, asymmetrically, no cost is incurred for converting the previous residential district into a business district since preventing environmental deterioration is not needed.

Suppose that each resident must incur the current conversion cost, C , per unit land area when the old business district (the area between the CBD and T_0 in Figure 1) is used as residence in the new configuration. Thus, the bid-rent of a household occupying that converted residential area is decreased by the conversion cost: that is

$$r_c^h(t) = W_c - P_c Z - k_c(t - T_1) - C \quad (30)$$

where T_1 is the new boundary between the business and residential districts in the new configuration. Thus, if $r_c^h(t) \geq 0$ (=opportunity cost), then land at location t is used as residence, while if $r_c^h(t) < 0$, land at t is not used but left vacant. This equilibrium configuration is depicted in Figure 3, where the area between T_2 and T_0 empties because $r_c^h(t) < 0$. In an extreme case, when C is very high, it follows that $T_2 = T_1$; that is, the new business district in the core city is perfectly separated from the residential district by a vacant area. Given C , if an edge city is formed, then the core city shrinks, and the land rent decreases overall. In particular, the land between T_2 and T_0 becomes vacant. Accordingly, the landlords of the existing core city will lose while the welfare of other agents in the core city, i.e., residents, office firms and commerce firms, will remain unchanged (the same utility and zero profit).

The negative effect of edge city formation on the core city is evaluated by two

alternative measures. The first measure is the rental revenue from the now vacant land which would have been obtained in the monocentric equilibrium: it is measured by $RKON1 = \int_{T_2}^{T_0} r_m(t) dt$. The second measure is the total reduction in rental revenue in the core city from the revenue obtained in the monocentric equilibrium: it is measured by $RKON2 = \int_0^D (r_m(t) - r(t)) dt$. Note that no loss in rental revenue occurs in the land between D and B since the developer of an edge city rents the land in that area at the prevailing market rent. The equilibrium conditions in this case are represented by Equations (3), (10), (16), (20), (21), (23) through (29), and the following two equations:

$$(D - T_0) + (T_2 - T_1) = N_c \quad (31)$$

$$W_c - P_c Z - k_c (T_2 - T_1) - C = 0 \quad (32)$$

In addition to 13 endogenous variables in the previous case, the variable T_2 is also endogenously determined. Equation (31) is the condition of population accommodation and Equation (32) is the condition where the rent at T_2 is equal to the opportunity cost of land.

4. Simulation analysis

4.1 Setting of the simulation

Since it is almost impossible to analyze theoretically the properties of an equilibrium under the two cities specified in the previous section, the numerical simulations were carried out to perform the comparative static analysis. The values and the variation area of the parameters were given as shown in the following Table.

C=0	C>0
$a=0.05$	$C=6.5, 7.0, 7.5$
$\beta=0.05$	$a=0.05$
$\theta=0.8$	$\beta=0.05$
$n=0.12$	$\theta=0.8$
$U=10.0$	$n=0.12$
$P=1200.0$	$U=10.0$
	$P=1200.0$

$=1.00\text{E-}4, 1.04\text{E-}4, 1.08\text{E-}4$	$=1.0\text{E-}4, 1.1\text{E-}4, 1.2\text{E-}4$
$k = 0.16, 0.18, 0.20$	$k = 0.20, 0.22, 0.24$
$k = 0.20, 0.22, 0.24$	$k = 0.28, 0.30, 0.32$

4.2 Where $C = 0$; no vacant business district phenomenon

The numerical simulation was carried out on the basis of the equilibrium conditions (3), (10), (16) and (20) through (29). That is, for the various values of the location E , the value of each endogenous variables was simulated to obtain equilibrium urban configurations. It was observed that the wage rate at the CBD and the price of composite goods in the core city increase monotonously with the location E while those prices in the edge city decrease monotonously with E . The share of core city in the metropolitan population increases with E because the farther the center of the edge city from the CBD, the weaker the competitive pressure on the core city.

Figure 4 shows how the developer's profit from edge city formation vary with the location of the edge city's center. The curve takes an inverted U-shape, which implies that there is, in general, a unique optimal location of E to maximize a developer's profits. As expected, the profit is smaller when $k_c \square k_f$ and δ are larger. The optimal location of E varies with the values of various parameters. The higher the communication cost of a commerce firm, k_f , the closer the location E to the CBD. This is because the business areas in both cities decrease in size as k_f increases. The optimal location of E deviates slightly farther from the CBD when k_c is increased. This is because the average commuting distance in an edge city is shortened as the number of residents commuting from the left-hand side to the new center increases. Naturally, the location of E moves closer to the CBD as δ increases.

We next investigate the equilibrium configurations corresponding to the optimal locations of E . Table 1 summarizes the comparative static analysis of the equilibrium structure with respect to changes in $k_c \square k_f$ and δ . When the commuting cost k_c increases, the wage rate W_c and the price of composite goods, P_c , in the core city increases while those in the edge city, W_e and P_e , decrease. The size of the core city, measured by D , increases with k_c . A change in the equilibrium configuration due to an increase in k_c is illustrated in Figure 5, which shows that increased commuting cost causes the rent at the CBD to rise and that at

the edge city center to fall. The size of the metropolitan area measured by H does not vary monotonously with k_c : it first shrinks, as k_c increases, but, above a certain value of k_c , it expands with k_c . The optimal location of the edge city center recedes farther from the CBD as k_c increases since, as described above, the mean commuting distance is shortened by increasing the number of residents commuting from the left-hand side to the edge city center. An interesting result is that the decrease in rental revenue in the core city from the previous level in the monocentric equilibrium configuration (as measured by RKON2) is smaller where the commuting cost is higher. The reason for this is that, as Figure 5 indicates, increased k_c will lower the rent in the residential district but raise it in the business district; more than offsetting the former reduction.

When the communication cost of commerce firms, k_f increases, the number of firms decreases, thereby raising the price of composite goods in both cities. The wage rate increases at the CBD while it decreases at the second center, E , as k_f increases. Total metropolitan population, N , decreases but the share of the core city increases with k_f . The optimal location of the second center approaches closer to the CBD, and the profit of the developer decreases as the communication cost increases. Figure 6 shows that, when k_f increases, the land rent is lowered overall in the core city and in most of the area of the edge city, whereby the loss of landlords in the core city (RKON2) increases.

As the decay rate of efficiency per unit distance from the CBD, δ , increases, the optimal location of E naturally approaches closer to the CBD, and the profits from edge city development decrease. In this situation, the wage rate and price of composite goods will fall in both cities, and the metropolitan population will decrease while the share of the core city increases. Figure 7 indicates that the land rent at the CBD lowers and the losses the landlords of the core city decrease with δ .

4.3 Where $C > 0$: emergence of a vacant business district

If the cost, C , for converting a business district to residential use is larger than a certain amount, then the land between T_2 and T_0 in the existing business district becomes vacant when an edge city is formed. That is, the area between T_2 and T_0 hollows out. A numerical simulation reveals that the effects of changing the location of E on the wage rate and price of composite goods are almost the same

as in the previous case (where $C=0$)³. It is ascertained that an increase in conversion cost will heighten the wage rate and price of composite goods in both of the two cities. As C increases, the population share of the core city in the metropolitan area decreases. A new endogenous variable, EMPTY, measuring the vacated land area ($T_0 - T_2$) is our particular concern. Figure 8 depicts that EMPTY takes an inverted-V shape in response to a change in the location of E . That is, the vacated land area in the core city begins to expand as the center of the edge city becomes farther from the CBD but, after some point, it shrinks with the distance between two centers, approaching zero. This implies that there is a location of the second center which brings about the largest vacated area. An interpretation of this is as follows. When the location of E is relatively close to the CBD, the competitive pressure on the business district in the core city is weakened, so that the business district is expanded (namely T_1 is extended) as the location of E recedes from the CBD. However, the rent at T_1 decreases, and thus the residents' bid-rent after paying the conversion cost, C , decreases, so that the area where that bid-rent is positive shrinks, whereby the location of T_2 approaches close to the CBD. Therefore, the area between T_2 and T_0 is enlarged. However, as the location E , is farther removed from the CBD, beyond a certain distant point the two locations of T_1 and T_2 coincide, and then the location of $T_1(=T_2)$ is moved away from the CBD with the location of E whereby the area between T_0 and T_1 decreases.

Figure 9 shows that, as C increases, the optimal location of E lies farther and farther from the CBD, and the profits of a developer decrease. The reason is that a larger portion of the existing business district is vacated, so that the residential demand of the CBD-commuters shows a relative increase in the area beyond T_0 , and thereby the location of E recedes from the CBD.

The losses of absentee landlords due to the "vacated" old business district, which are measured by RKON1, naturally increase with C , and the function takes an inverted-V shape with respect to a change in E . On the other hand, the entire losses of the landlords of the original core city, measured by RKON2, monotonously decrease with the distance between the CBD and E , and these losses are larger when the conversion cost, C , is larger.

Considering the comparative static result concerning a change in δ . As Figure 10 shows, the larger δ , the closer the optimal location to the CBD and the smaller the profits of a developer. An interesting observation here is that the vacated area is

larger when δ is smaller (Figure 11). One interpretation is that when δ is smaller, the optimal location of E recedes from the CBD, and thereby the business district in the core city expands (T_1 is extended). However, since the rent at the extended T_1 is lowered, the bid-rent for residence after the conversion cost, C , is deducted at T_1 decreases and, as a result, T_2 moves closer to the CBD.

Table 2 summarizes the comparative static results where a developer chooses an optimal location of E when there is a conversion cost. Even if the conversion cost increases, the optimal location of E is almost unchanged, but the profits of a developer decrease. A typical change of equilibrium configuration due to a change in C is depicted in Figure 12. The rents at both the CBD and the second center are lowered when C is increased. Increased conversion cost reduces the population in a metropolitan area and lowers the population share of the core city, since the vacated area in the core city expands as C increases. Increased RKON2 implies that the welfare of the landlords of the core city is lowered by an increase in C .

A change in the equilibrium urban configuration caused by the commuting cost increase is illustrated in Figure 13. The effect of increased k_c reveals many differences (compare Table 1 and 2). When commuting cost increases, the wage rate and price of composite goods are lowered, the business district shrinks, and the population decreases in the core city. Another difference is that the rent at the CBD decreases as commuting cost increases. Trends common to both Table 1 and 2 are that: as commuting cost increases, the optimal location of E recedes from the CBD; the profits of a developer decrease; the vacated area expands; and the losses of absentee landlords from the vacated business district necessarily increase. A notable difference of Table 2 from Table 1 is that the total reduction of rental revenue in the core city, i.e., RKON2 increases as commuting cost increases. This is because the rent in the business district of the core city is also lowered due to the vacated land.

The effects of increased communication cost for a commerce firm are similar in both Table 1 and 2. A big difference is that, as k_f increases, the core city share in metropolitan population decreases when a vacated business district emerges, but increases when $C = 0$. This is reflected in a decrease in the price of composite goods in the core city. As k_f increases, the optimal location of E approaches the CBD, and the profits of a developer decrease. An equilibrium configuration is drawn in Figure 14, where the vacated area expands and the welfare of absentee landlords decreases when k_f increases.

The effects of an increase in δ in Table 2 are almost the same as those in Table 1. An equilibrium configuration is shown in Figure 15. As δ increases, E moves towards the CBD, and the profits of a developer decrease. When δ increases, the vacated area decreases but the rental revenue decreases more compared with the level in the monocentric equilibrium: that is, the value of $RKON2$ increases.

The analysis so far suggests that not only a reduction in cost for converting a business district into residence, but also an improvement in transportation system to lower the cost for commuting and communicating will contribute to minimizing the losses from the vacated business district caused by the edge city formation.

It is unavoidable that the absentee landlords of the core city lose when an edge city is newly formed, whether in or outside the existing monocentric core city, and these losses are greater where some parts of the existing business district are vacated due to the large conversion cost. On the other hand, a developer will surely gain profits as a result of the formation of an edge city. If transfer between the landlords of the core city and the developer of an edge city is possible, and the total social benefit measured as a sum of the (negative) absentee landlords' losses and the (positive) developer's profit is positive, then the formation of an edge city will be socially acceptable. In the present simulation, the total social benefit was calculated as

$$SB = \pi_D - RKON2 \quad (33)$$

For given values of the parameters, the simulated values of SB were overwhelmingly positive: the comparative static concerning SB are shown in the last column in Table 2. The social benefit decreases as C , $k_c \square k_f$ and δ increase, which results are intuitively acceptable.

5. Concluding remarks

The effects of an edge city formation on the existing core city have been investigated focusing on the vacated business district in the existing core city. The basic model was constructed with the hypothesis that the existing business district shrinks due to a new edge city formation, and some portions of that district are vacated (a phenomenon experienced very often in many Japanese cities) because considerable costs are incurred to convert the existing business district into new residence. A new equilibrium configuration after the formation of an edge city was

analyzed and losses due to the vacated business district, as well as the welfare decrease of absentee landlords due to its formation were numerically analyzed. It is concluded that improvement in the transportation system, to lower commuting and communication costs, can contribute to minimizing the losses of a vacated business district caused by edge city formation.

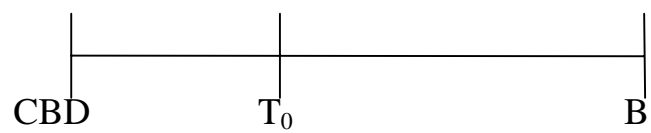


Figure 1

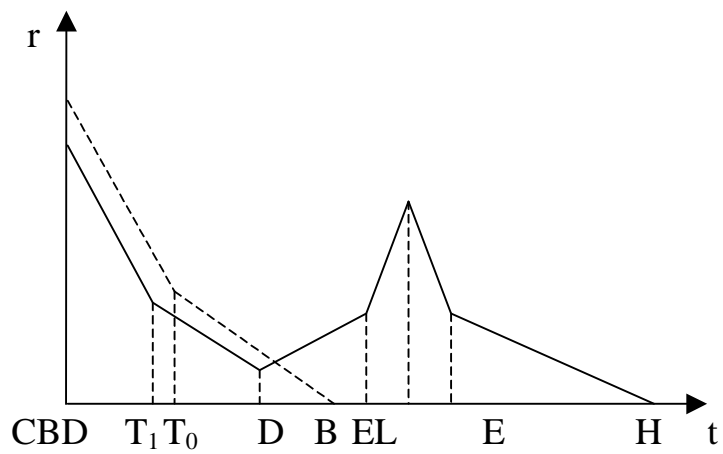


Figure 2

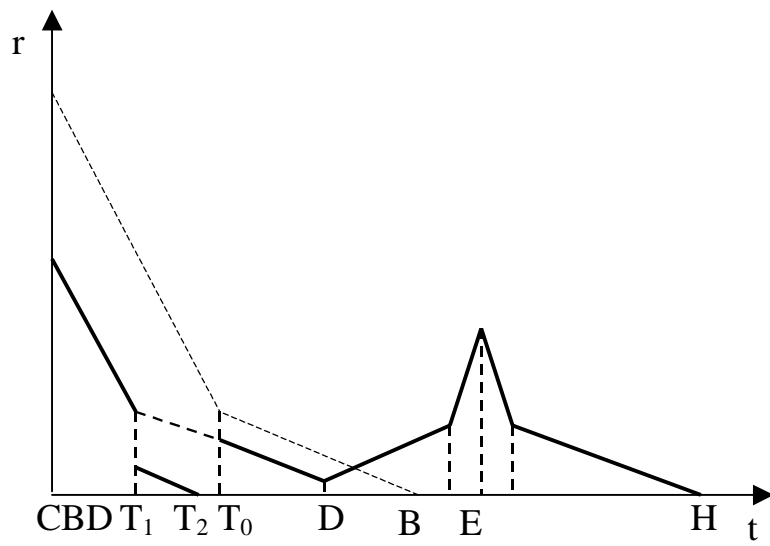


Figure 3

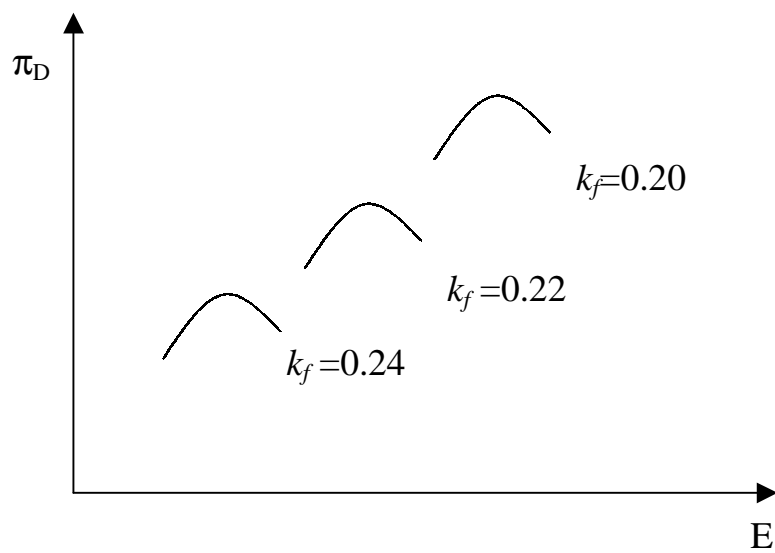


Figure 4-1

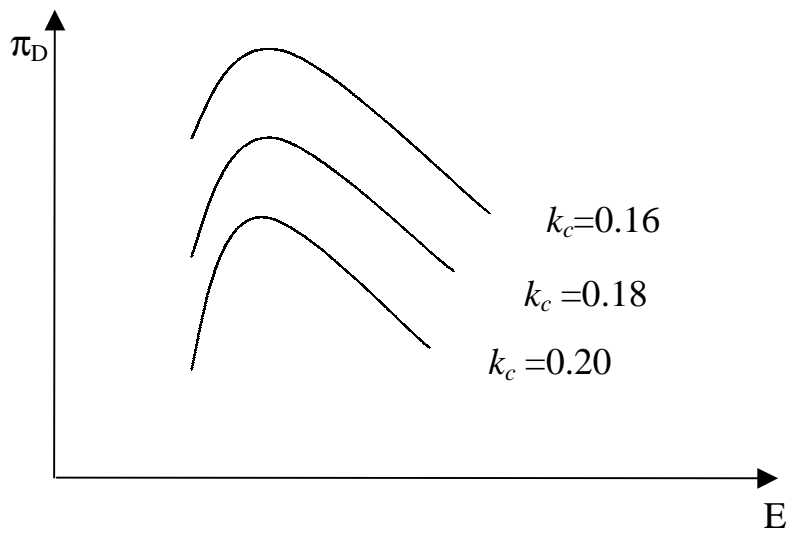


Figure 4-2

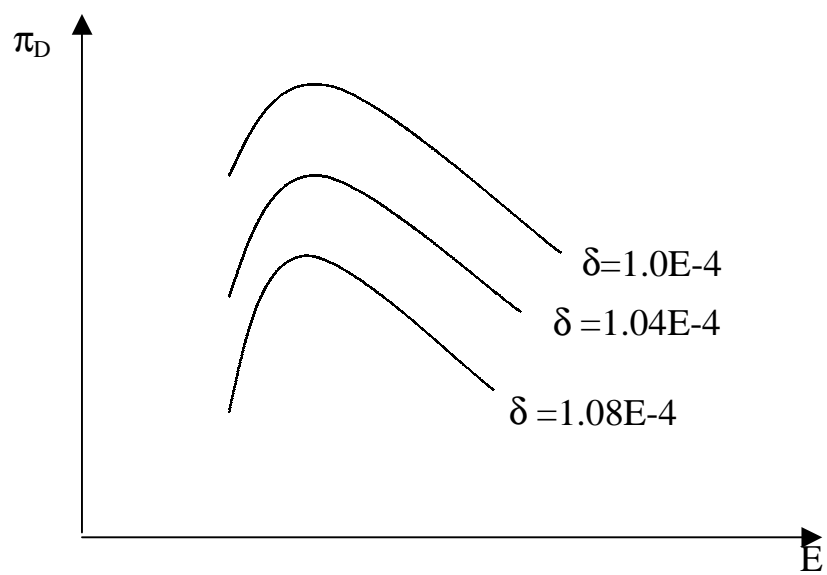


Figure 4-3

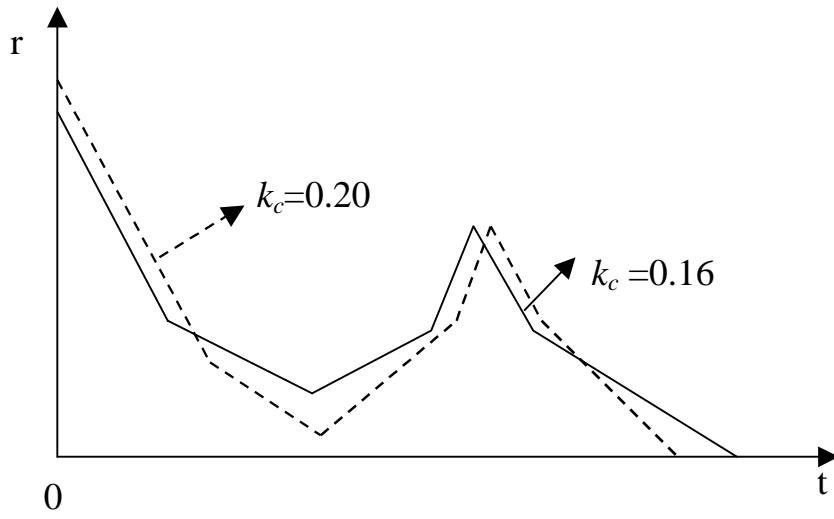


Figure 5

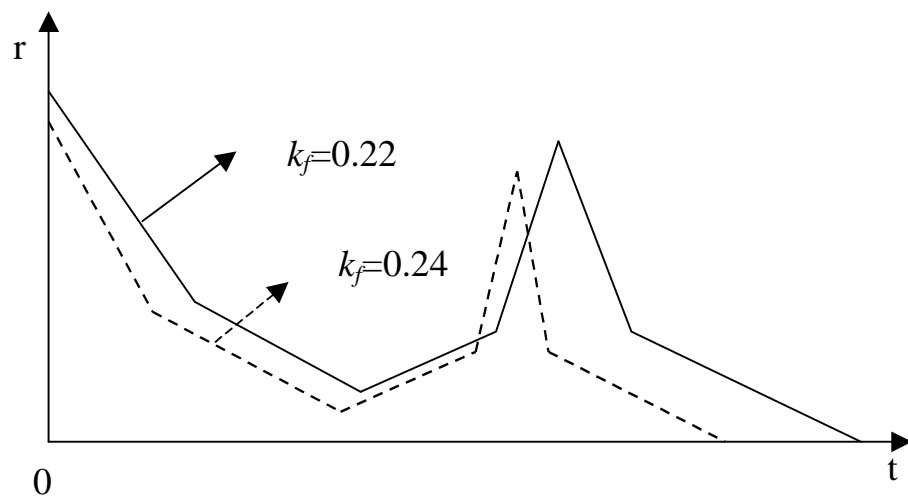


Figure 6

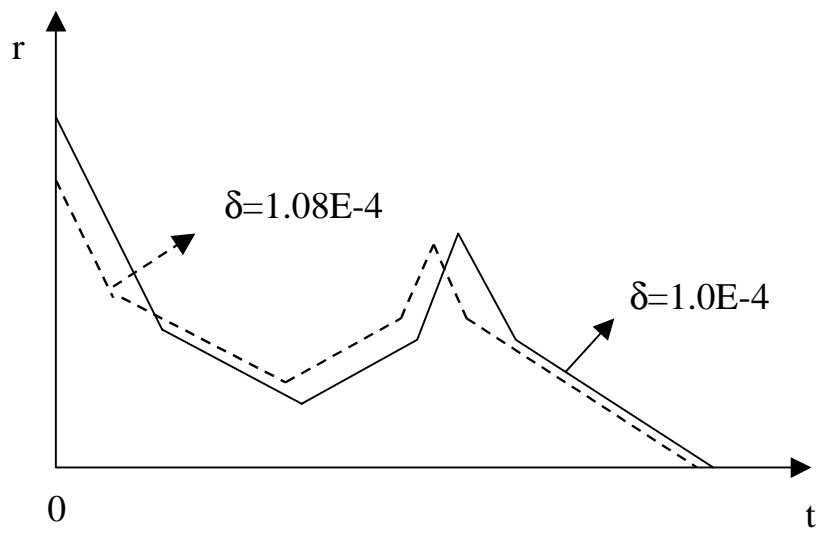


Figure 7

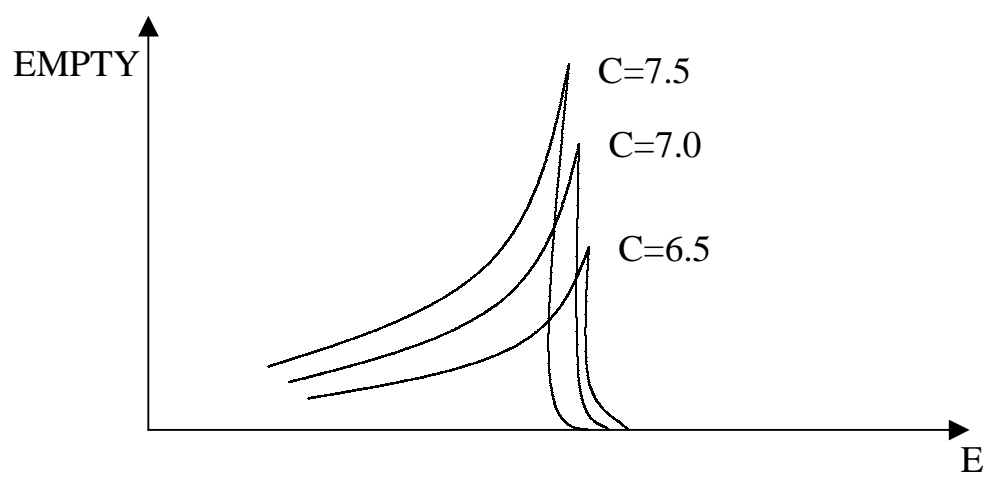


Figure 8

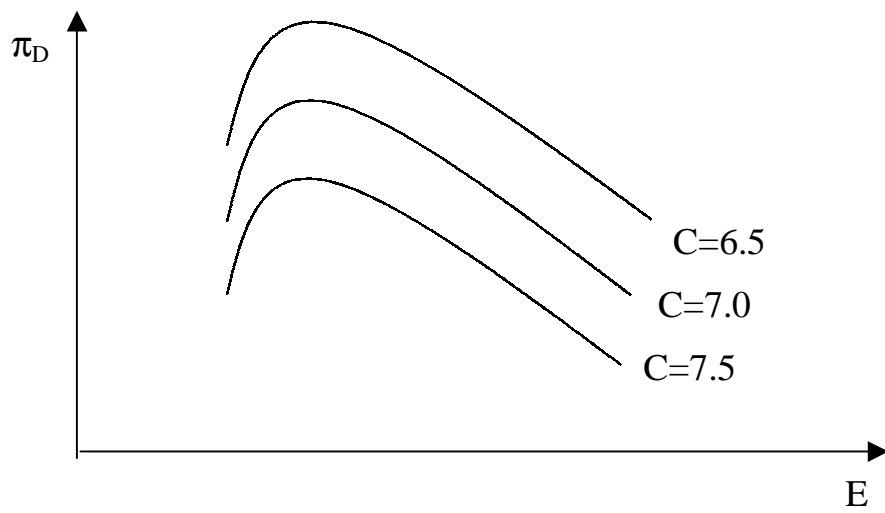


Figure 9

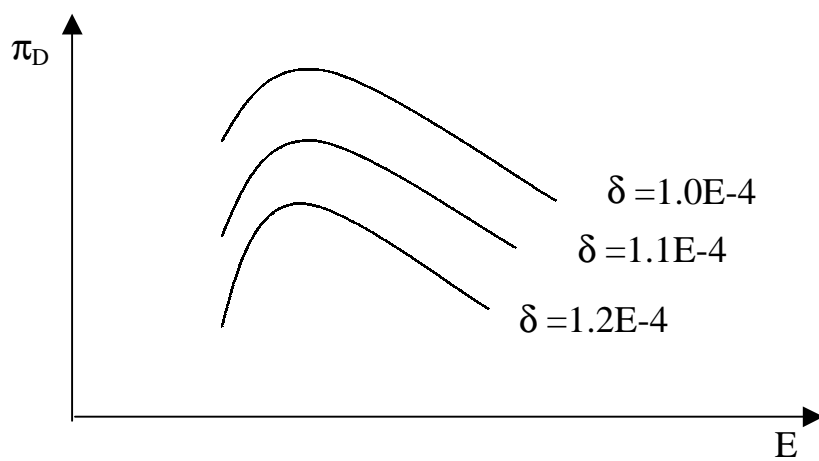


Figure 10

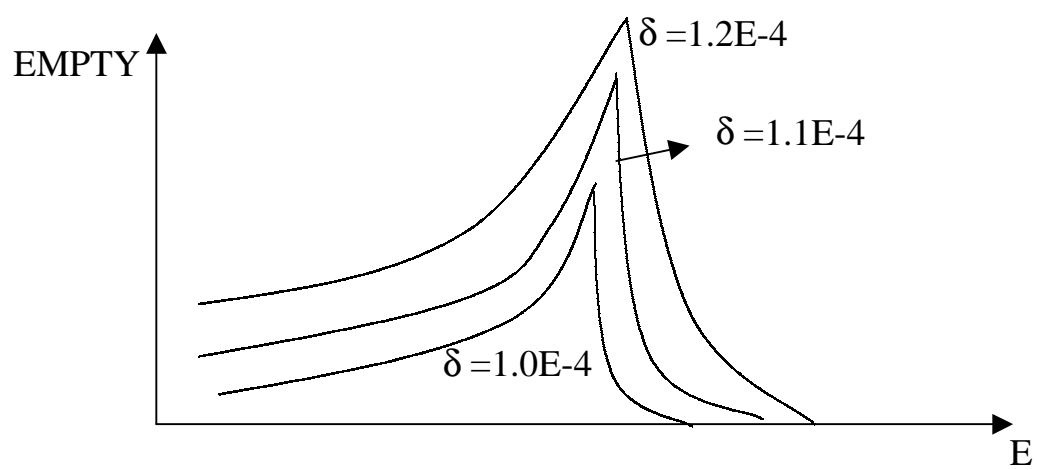


Figure11

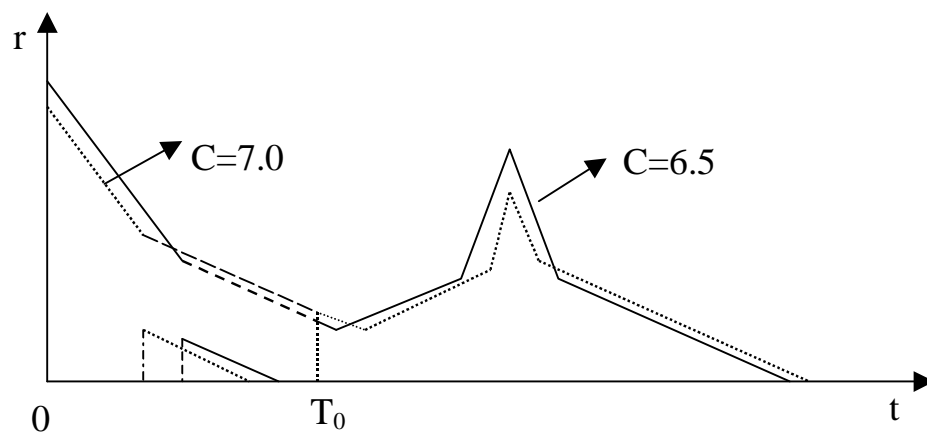


Figure 12

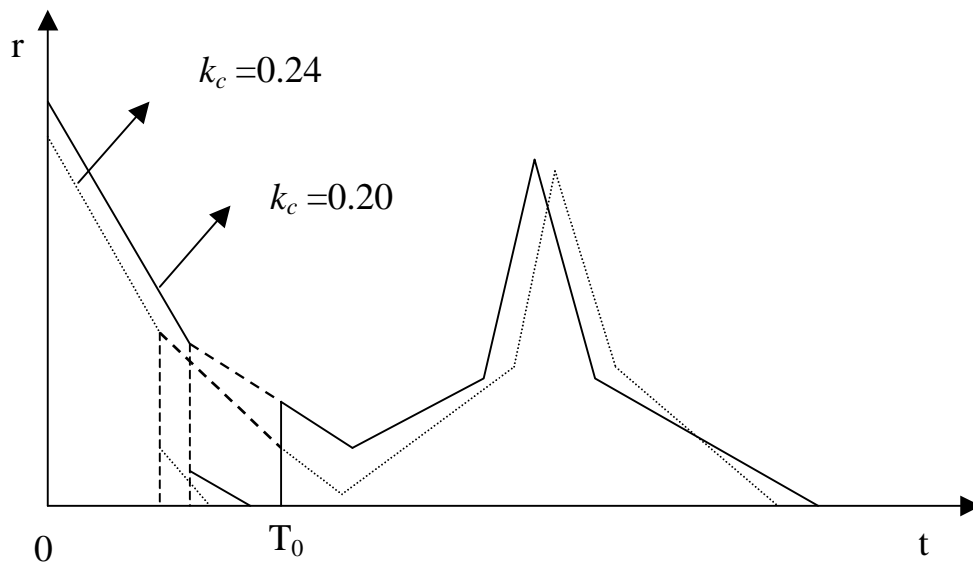


Figure 13

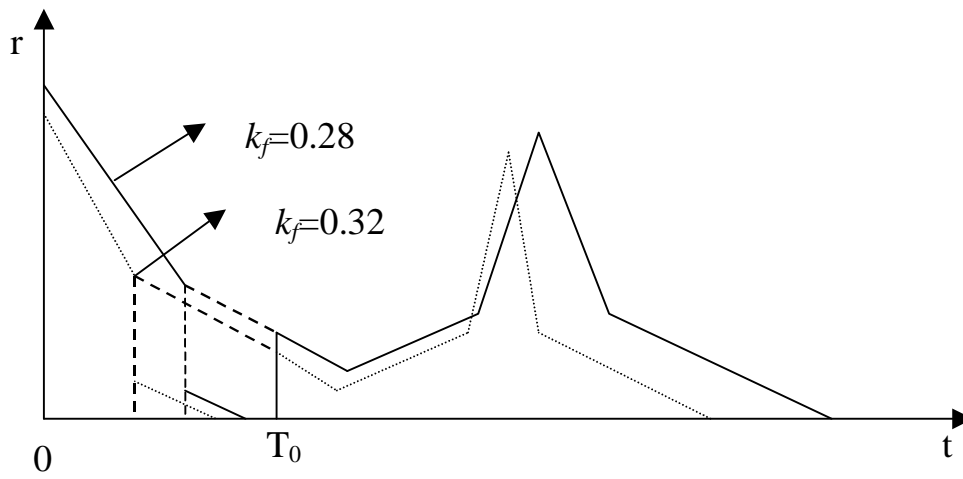


Figure 14

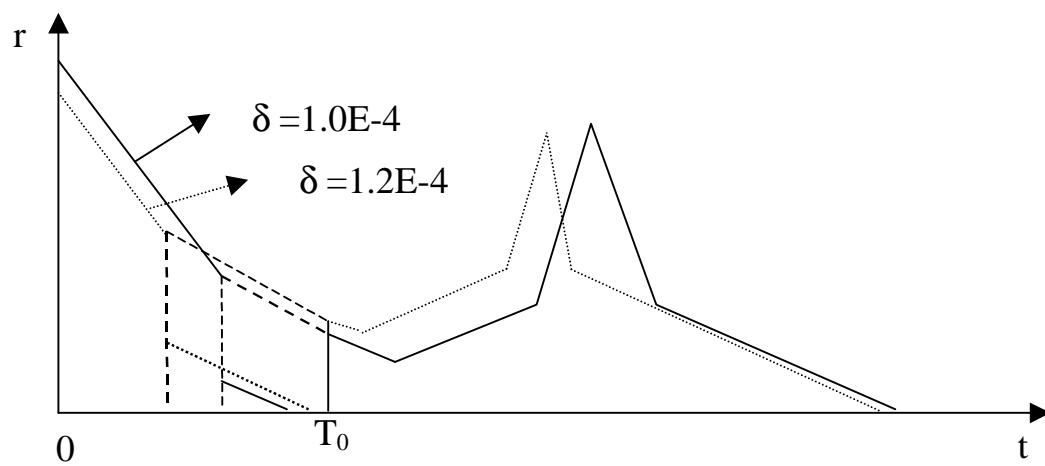


Figure 15

Table1. Comparative static analysis results of case C=0

	W_c	W_e	N_c	N_e	N	N_c/N	P_c	P_e		
Increase in K_c	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> , <input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
Increase in k_f	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
Increase in δ	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	T_1	D	EL	ER	H	R_c	R_{T1}	R_D	R_{EL}	R_e
Increase in k_c	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> , <input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Increase in k_f	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Increase in δ	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	E	π_D	RKON2	TRCF	TRCC	TREF	TREC			
Increase in k_c	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			
Increase in k_f	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			
Increase in δ	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			

Table2. Comparative static analysis results of case $C>0$

	W_c	W_e	N_c	N_e	N	N_c/N	P_c	P_e
Increase in C	\square	\square	\square	\square	\square	\square	\square	\square
Increase in k_c	\square	\square	\square	\square	\square	\square, \square	\square	\square
Increase in k_f	\square	\square	\square	\square	\square	\square	\square	\square
Increase in δ	\square	\square	\square	\square	\square	\square	\square	\square

	T_1	T_2	D	EL	ER	H	R_c	R_{T1}	R_D	R_{EL}	R_e
Increase in C	\square	\square	\square	\square	\square	\square	\square	\square	\square	\square	\square
Increase in k_c	\square	\square	\square, \square	\square	\square, \square	\square	\square	\square	\square	\square	\square
Increase in k_f	\square	\square	\square	\square	\square	\square	\square	\square	\square	\square	\square
Increase in δ	\square	\square	\square	\square	\square	\square	\square	\square	\square	\square	\square

	E	π_D	EMPTY	RKON1	RKON2	TRCF	TRCC	TREF	TREC	SB
Increase in C	0	\square	\square	\square	\square	\square	\square	\square	\square	\square
Increase in k_c	\square	\square	\square	\square	\square	\square	\square	\square	\square, \square	\square
Increase in k_f	\square	\square	\square	\square	\square	\square	\square	\square	\square	\square
Increase in δ	\square	\square	\square	\square	\square	\square	\square	\square	\square	\square

Footnotes

1. For instance, the Yomiuri reported in June 29, 1998 that 48 stores of 120 in the central commerce street in the Ube city (a famous industrial city in Yamaguchi prefecture) are closed; and the Asahi reported on September 6, 1998 that 35 shops of 220 in the central street in Tochigi city (a city of regional center in Tochigi prefecture) are closed. It is reported that in central streets in forty percent of all cities in Japan, about ten percent of stores are closed.
2. Such fare system is employed in some urban models with subcenter (e.g., Sasaki [1990] and Sivitanidou & Wheaton [1992]).
3. In both cases, we could obtain unique equilibrium solutions for each endogenous variable, although the equation system has some non-linear parts. This is because the system was solved subject to the constraint, $D < B < EL$.

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