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ECONOMIC ANALYSIS
OF THE GREENBELT AMENITY
IN SEOUL, KOREA

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Joo An Kwon

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W Paul Strassmann
Major professor

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ECONOMIC ANALYSIS OF THE GREENBELT AMENITY IN SEOUL, KOREA

By

Joo An Kwon

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ABSTRACT

ECONOMIC ANALYSIS
OF THE GREENBELT AMENITY
IN SEOUL, KOREA

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Joo An Kwon

In Korea the metropolitan area of Seoul is surrounded by the restricted area, which is called as the Greenbelt, and starts at 10-18 *km* from the CBD. As the economic growth continues with high income, there has been a strong pressure from the demand side of the housing and land markets to demand more of urban residential land and floor space. The Greenbelt has been blamed as restraining physically the area from being developed into urban uses and has to be adjusted to meet the increasing demand pressure in Seoul. Along with the deregulation mood in Korea, attacks to the Greenbelt seem to lead the total abolition of the system. Kim(1987) asserted that if the Greenbelt is released by 1 *km* wide, then 7.7% decrease of land rent is estimated by using 1976 survey data.

If the Greenbelt has an amenity effect and makes a positive environmental contribution to the areas adjacent to the Greenbelt, then the net social gain must consider these positive externalities of the Greenbelt. In order to find the net social gain of releasing the land from the Greenbelt, we have to estimate the rent gradient with the amenity effect considered as a function of the distance from the Greenbelt. Using the linear spline estimation with the semi-log specification of the rent gradient, the rent gradient with the amenity effect of the Greenbelt is estimated. Based on these results, we calculate the new net social gain of releasing the land from the Greenbelt; and if the

width of the Greenbelt matters, it is found to be smaller than previously without considering the amenity effect.

Amenity effect of the Greenbelt illustrates that it is desirable not to abolish all the Greenbelt system but to adjust the present system to produce the same amenity effect. We introduced the Green Disks as an alternative to the Greenbelt, and the Green Disks are preferrable to the Greenbelt because they spend less land for restriction. Also, Urban Disks are considered, but the Green Disks are superior. According to our findings of net social gain and the Green Disks, we build an examplary alternative form of the Greenbelt.

dedicated to
my grandparents, parents, wife and son

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TABLE OF CONTENTS

List of Tables

List of Figures

Chapter I

I. Introduction

The simplest model in urban economics assumes that a city is monocentric. It is a long-run equilibrium model and built up with the assumption of homogeneous housing services. Various implications stem from the basic trade-off between accessibility and residential space. It has strong analytical power but ignores the heterogeneity of housing services in the real world. Introducing heterogeneity cannot guarantee trouble-free models since we have to bear some costs: losses in analytical simplicity and empirical application. The best way to deal with such problems is a compromise between realism and analytical power.

Greenbelts may introduce some heterogeneity in urban economics with other attribute variables. If an amenity from the Greenbelt varies with the distance to the Greenbelt, housing on different parcels will provide a different degree of amenity. It brings the simple monocentric model closer to reality. On the other hand, because the Greenbelt is established around the urban areas, the monocentric model could exhibit its full analytical power in explaining the amenity effect of the Greenbelt. Therefore, our analytical model is basically monocentric with some heterogeneity of the amenity effect.

In Korea the deregulation movement seems to flourish since the first civilian president was elected in 1993. In line with the deregulation movement, the Greenbelt is criticized for its pervasive effect on the urban land supply in Seoul and other major cities. In this study we analyze the amenity effect of the Greenbelt and reconsider the validity of the deregulation movement.

First, we show that the amenity effect of the Greenbelt exists in the land market. Amenity effects basically depend on the distance from the Greenbelt boundary. Second, if the amenity effect exists, then the social gain from releasing the Greenbelt restriction may be less than expected since the amenity gives a positve benefit to the residents near the Greenbelt. These amenity benefits depend on how thick the Greenbelt is and how wide the restricted area is released. Because the Greenbelt is not changed yet, we cannot observe the amenity changes or rent gradient after the land release and do not have clear information about how the amenity benefit should be specified. For calculation of the net social gain, we simply assume that amenity benefit can be calculated from the rent gradient, and the rent gradient shifts vertically due to land release. Third, we introduce the Green Disks and urban disks as an alternative system to the Greenbelt. The deregulation movement of the Greenbelt leads many to conclude that it must be abolished. However, if the Greenbelt has some merits, then it may be better to adjust the system partially to preserve such merits than to abolish it entirely.

1. The Greenbelt

The Greenbelt restriction is one of many growth controls. The Greenbelt is designed to contain the growth of urban areas. The Greenbelt has a long but intermittent history. The first idea ever of the Greenbelt may be found in the Old Testament which describes towns and cities with inviolable rural hinterlands -- Numbers 35:1-4 and Leviticus 25:34 (see Osborn, 1946, pp.167-180).

> On the plains of Moab by the Jordan across from Jericho, the Lord said to Moses, "Command the Israelites to give the Levites towns to live in from the inheritance and

Israelites will possess. And give them pasturelands around the towns. Then they will have towns to live in and pasture lands for their cattle, flocks and all their other livestock. The pasturelands around the towns that you give the Levites will extend out fifteen hundred feet from the town wall. ·····" -- **Numbers 35:1-4**

But the pastureland belonging to their towns must not be sold; it is their permanent possession. -- **Leviticus 25:34**

Later authors, such as Sir Thomas More (Utopia), Robert Owen and J. S. Buckingham contributed to the idea that town and country should be functionally related but physically distinct (see Thomas, 1970, p.72). The first systematic concern of the Greenbelt was introduced in London -- the 1580 proclamation of Elizabeth established a cordon sanitaire three miles wide around London -- to check the further growth of a large built-up area, to prevent neighboring towns from merging into one another and to preserve the special character of a town (see Munton, 1983, pp.15-29; Thomas, 1970, pp.72-96; Mandelker, 1962, p.31).

The Greenbelts were also introduced in the United States as a Garden City or Greenbelt Town; Greenbelt in Maryland outside Washington D.C., Greendale in Wisconsin outside Milwaukee and Greenhills in Ohio outside Cincinnati, three Greenbelt Towns begun by the New Deal's Resettlement Administration in 1936. At that time the Greenbelt Towns were an experiment in urban living. Different from the Greenbelt in London, the three Greenbelt Towns were very small in population and urban area. In the late 1970's and early 1980's another application was done in Boulder, Colorado; Portland, Oregon and California as an urban growth boundary or one of growth controls.

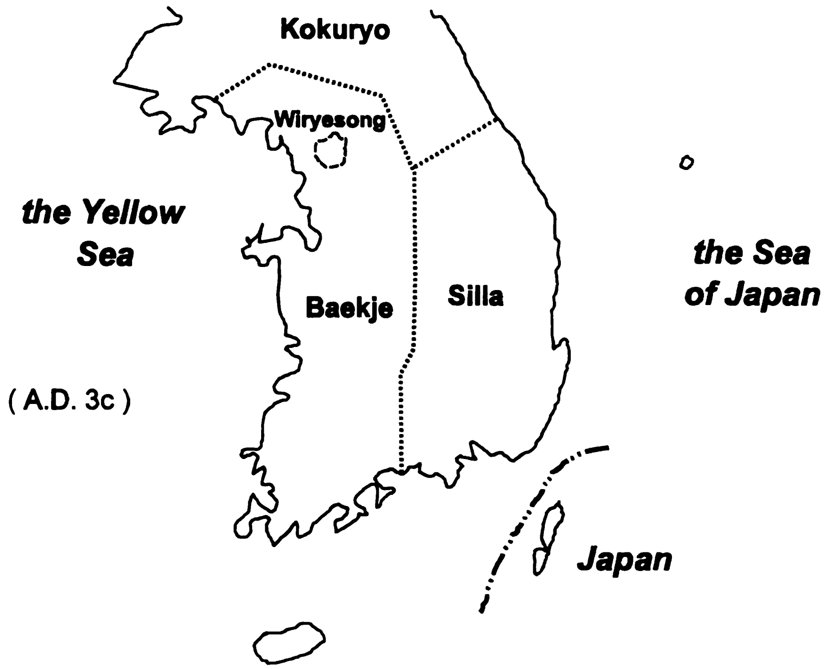
2. The Greenbelt in the Capital Region

Once called Wiryesong, the capital of Baekje Kingdom, Seoul has been the most important geo-political center in Korean history. As the town expanded and formed its rudimentary structure during the Koryo Dynasty, Seoul was one of three capital towns called Namgyong. Six hundred years have passed since Seoul became the capital of the Choson Dynasty in 1394. Hansongbu, another old name of Seoul, had a hundred thousand population at that time, but has reached 1.4 million in 1945 and ten million now. Also the city area has expanded from 16.5 km^2 in 1394 to 627.06 km^2 in 1994. Seoul has changed from a fortress town into a gigantic metropolis (see <Figure 1>.).

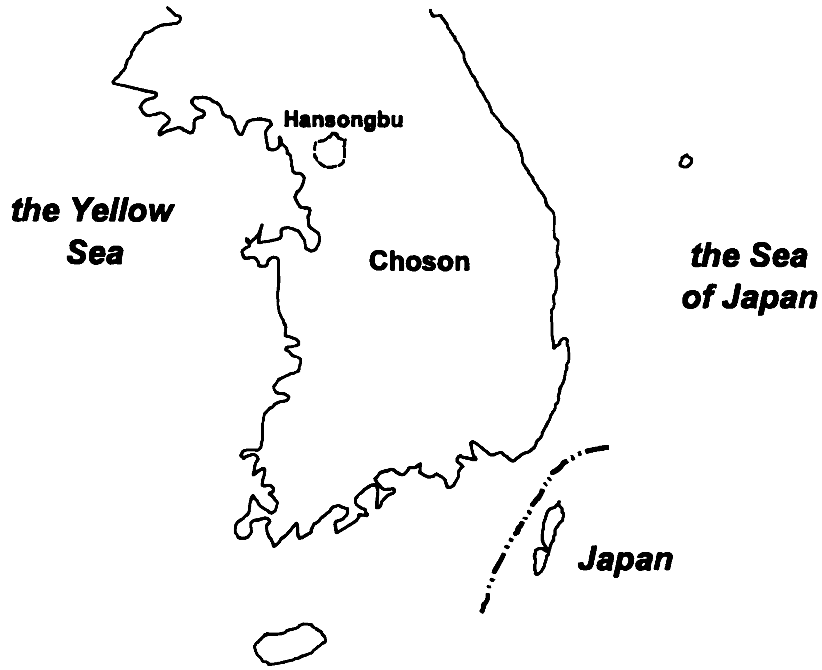
At the beginning of the 1970's the city planning began to focus on the control of growth as the overconcentration problem became a major planning issue among large cities. The period after the 1970's was a transition toward a modern city. Bristling high-rise office buildings appeared in the urban renewal areas and Kangnam (southern part of Han River in Seoul) was developing with construction of many apartments. Subcenters or secondary centers also grew in Seoul and small satellite cities such as Euijongbu, Songnam, Kwangmyung, Buchon and Anyang began to form.

The Greenbelt was designated in major cities in Korea between 1971 and 1977 for the purposes of land use control and containment. The total area of the Greenbelt was 5397.1 km^2 as of 1988 and about 5.5% of the total area of Korea. This number is relatively small compared with the total area but since it is imposed around the urban boundaries, the physical restriction is quite large. The Greenbelts are designed to serve the functions of preventing irregular physical expansion of cities, protecting the environment and securing national defense. The Urban Planning Law prohibits land use conversions and construction activities other than rebuilding or altering an existing structure inside the Greenbelt.

Figure 1. Seoul in Korean History



(a) Three Kingdoms:
Kokuryo, Baekje and Silla (A.D. 3c)



(b) Choson Dynasty
(A.D. 14c)

As noted, the Greenbelt has had a pervasive effect on the urban land supply. Population kept on increasing steadily in Seoul with rapid economic growth and urbanization while the boundary of Seoul is fixed by the Greenbelt. Population growth has consequently brought a highly dense development in Seoul. The shortage of residential land in Seoul has been partially filled by decreasing other land uses.

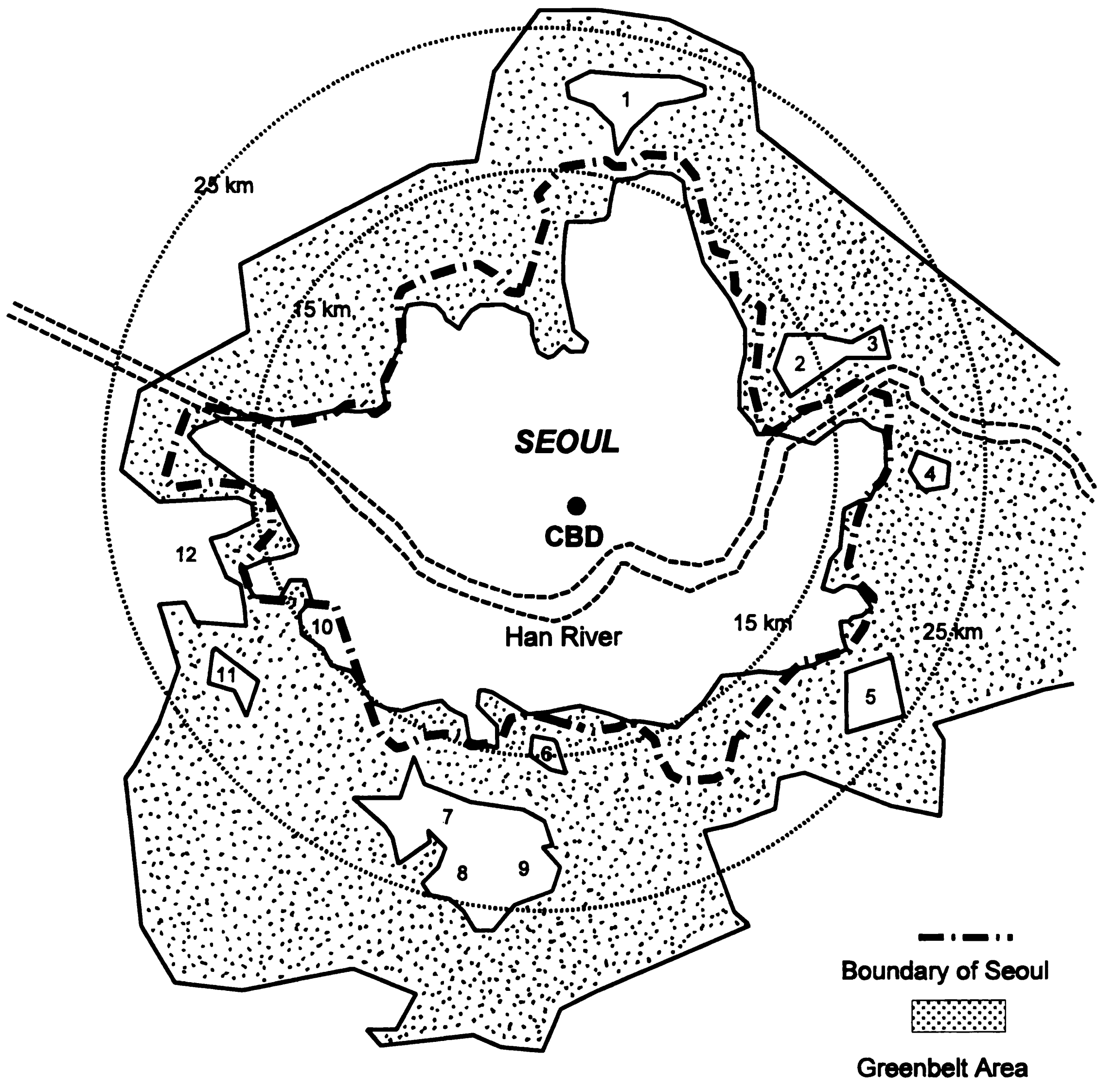
< Table 1 > Greenbelts in the Capital Region and Kyonggi Province as of 1988 (km^2)

Region	Total Area (1)	Greenbelt (2)	(2)/(1) (%)	(2)/{(1)-(2)}(%)
(a) Seoul	605.4	166.8	27.6	38.0
(b) Inchon	310.8	55.2	17.8	21.6
(c) Other Cities	1178.2	670.8	56.9	132.2
(a)+(b)+(c)	2094.4	892.8	42.6	74.3
Rest of Kyonggi*	9584.3	658.9	6.9	7.4
Total	11678.7	1551.7	13.3	15.3

Source : *Municipal Yearbook of Korea*, MOHA, Seoul, 1989.
* : Kyonggi Province is one of nine provinces in Korea and it encompasses Seoul.

<Table 1> illustrates the current status of the Greenbelt in the capital region. The Greenbelt in the capital region starts at 10-18 *km* from the center of Seoul and expands 10-
15 *km* outward to cover parts of Inchon, 14 other cities and 8 counties. The Greenbelt is 42.6% in the total urban area and 27.6% in Seoul. Most area in the Greenbelt is composed of forest and arable land, and only 5.6% (4.0% and 4.4%) is developed for residential use in the capital region (Seoul and all urban areas respectively). <Figure 1-1> illustrates the locations and areas of the Greenbelt around the capital region. The Greenbelt is established around the Seoul area, and its inner boundary shows a shape similar to the administrative boundary. Also the satellite cities are surrounded by the Greenbelt.

Figure 1-1. Capital Region and Greenbelt



Satellite Cities

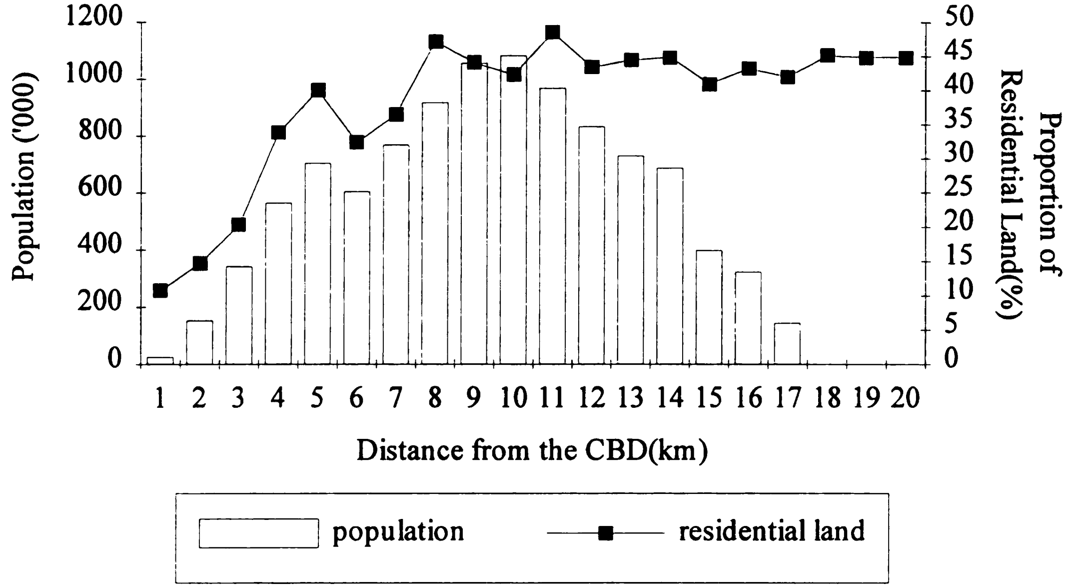
1	Eujeongbu	7	Anyang
2	Guri	8	Gunpo
3	Migum	9	Euwang
4	Hannam	10	Kwangmyung
5	Sungnam	11	Siheung
6	Kwachon	12	Buchon

Before going on to the theoretical analysis, it is desirable to see the spatial distribution of population and residential area in Seoul. <Figure 2-(a)> shows the total population and the proportion of the residential area to the total developed area in the corresponding circular area according to the distance from the central business district. The proportion of the residential area increases steadily until 8 *km* and remains about 45% afterwards. The population shows an inverse U-shape. It increases until 10 *km* where it reaches the maximum and after 10 *km*, it decreases. Considering that the Greenbelt starts at 10-18 *km* from the CBD and the proportion of the residential area remains steady around 45% after 8 *km* from the CBD, the population is concentrated relatively in the adjacent area to the Greenbelt.

Even though the proportion of residential land does not show any decreases at locations of 11 *km* from the CBD, the density on residential land may actually increase as the total developed area falls more than population declines with distance from the CBD. In <Figure 2-(b)>, we show the two different population densities with respect to the total developed area (*density 2*) and the residential area (*density 1*). While the density to the residential area increases so sharply that it reaches the highest level at the range of 2-3 *km*, the density to the total developed area reaches the highest level at the range of 13-14 *km*. In case of the *density 1*, the residential area is relatively small to the total developed area at the range of 2-3 *km*, and this makes the *density 1* high and the *density 2* low. Two densities are high at the range of 13-14 *km* since the residential and commercial areas are developed more densely (especially in the southern part of Seoul), and population size is higher than the residential area relatively to the other areas in Seoul. We can see that population is concentrated relatively heavily in the areas adjacent to the Greenbelt.

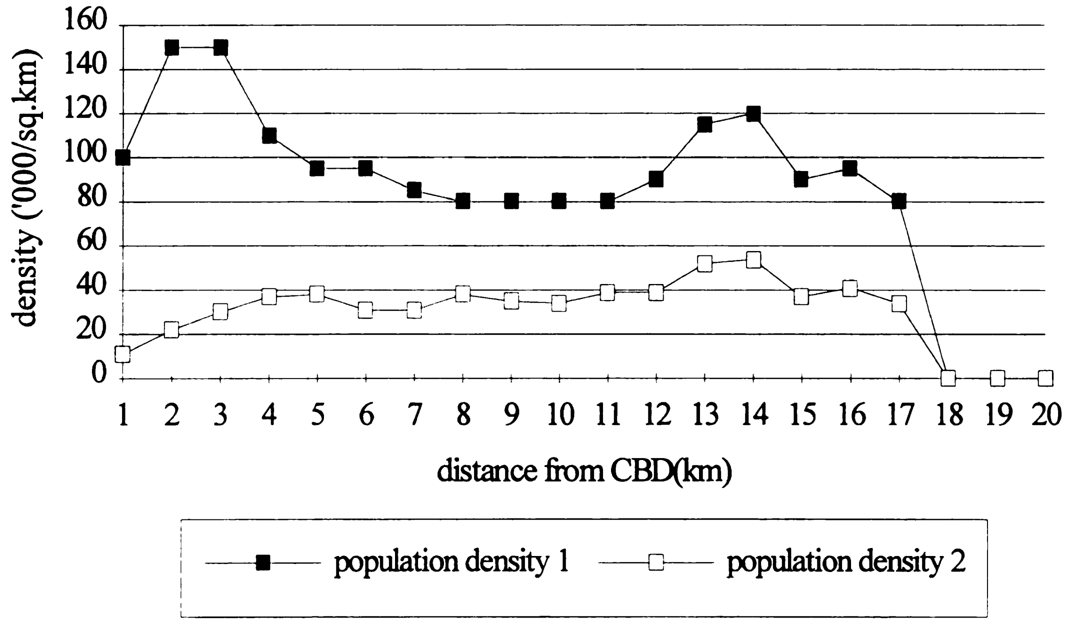
Figure 2. Population Densities and Residential Land in Seoul (1988), and Average Land Rent in Selected Years

(a) Population Distribution and Residential Land



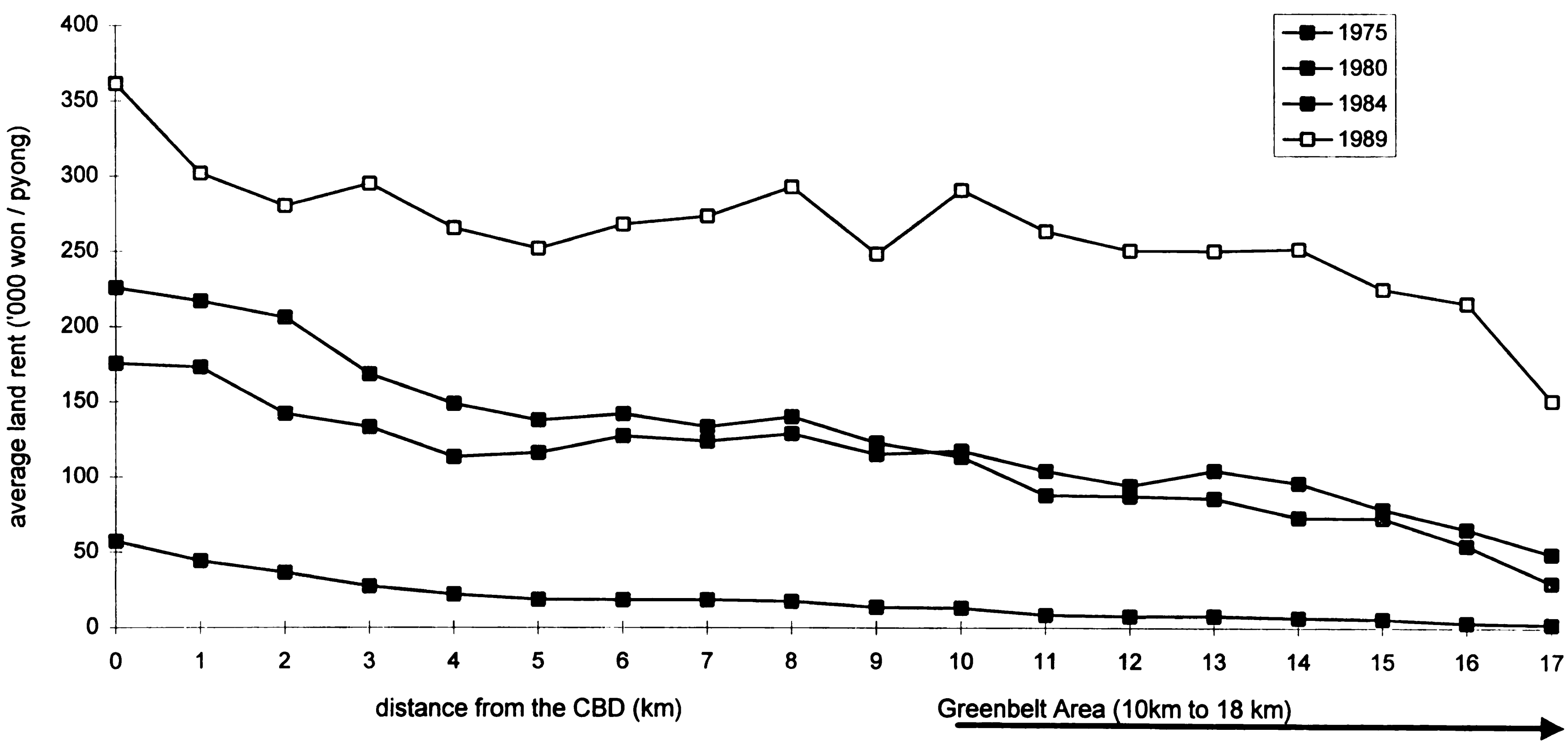
Note : The Greenbelt begins at 10 - 18 km from the CBD.

(b) Two Population Densities



Note : population density 1 = population ÷ residential area
population density 2 = population ÷ total developed area.

(c) Average Land Rent in Selected Years



<Figure 2-(c)> shows the average land rent of Seoul in selected years. Land rent is decreasing with the distance from the CBD in all selected years. When we compare the land rent in 1980 and 1984, the average land rent is shown to rotate counter-clockwise around the area of 9-10 *km* from the CBD. The Greenbelt starts at 10 *km* from the CBD, and during the period of 1980-1984 land rent increases relatively higher at the areas adjacent to the Greenbelt.

3. Previous Studies

The Greenbelt is one of many measures for growth controls. Brueckner (1990) illustrates the effect of growth controls on the land values in an open city setting. In an open city model population changes to restore the previous equilibrium. Pogodzinski and Sass (1992), Engle et al. (1992), Landis (1992), and Fischel (1989) provide a good survey of growth controls, and they tried to illustrate the goods and bads of many growth controls measures. Cheshire and Sheppard (1989), Zorn et al. (1986), Knapp (1985), and Ohls et al. (1974) are a few of many empirical studies about effects of growth controls on land and property values.

Growth controls are designed to check and adjust the urban growth in the long run. Capozza and Helsley (1989) provide the fundamental factors of land prices in the long run. Land prices are composed of discounted value of urban land rent, conversion costs, and agricultural rent. For area near the Greenbelt there is one more factor to be considered, and it is an amenity effect of the Greenbelt. As Nelson (1988) pointed out, the rent gradient is higher near the Greenbelt due to amenity effect. Polinsky and Shavell (1976) considered the amenity effect in the closed and open city models. Utility function is defined to include the amenity variable, and because land rent gradient carries enough information about the amenity effect in utility function, the amenity effect can be traced

out from the estimated rent gradient in both closed and open models. Diamond (1980) used a modified Box-Cox specification to estimate the amenity effect on the urban land prices. He found that the specification of functional form is very important in estimating the amenity effect. General Box-Cox functional form is chosen and preferred by most researchers of the amenity effect. But maximum likelihood estimation does not necessarily guarantee the global maximization. We choose a simple linear estimation over the nonlinear maximum likelihood estimation because it is easier to estimate and interpret.

Most Greenbelt studies have been done on the London's Greenbelt because London has the longest history of the Greenbelt. Thomas (1970) attempted to show how the stricter controls over land usage, implicit in the Greenbelts, have led to modifications in the use of land over the zone surrounding London. He illustrated the changes in population, land uses, and industrial redeployment. He emphasized the containment role of the London's Greenbelt, and it was found to be successful by using 1960 data. Munton (1983) pointed that the implementation of the Greenbelt restriction raises many complex issues. This is partly because the purpose of the Greenbelt in London can be interpreted in widely differing ways and partly because today's substantial Greenbelt encompass a great range of local planning situations. Interpretative gaps between local and central government were found to be critical in the size of the Greenbelt, determining the Greenbelt boundaries, and environmental issues. Under these confusion of practising the Greenbelt farmland has been maintained very poorly. Elson (1986) pointed that the Greenbelt in London is a successful example of reconciliation invented for planning profession. He also sorted out several effects of the Greenbelt; (i) it has managed the process of decentralization into specific physical forms. (ii) it has contained patterns of new development in the interests of economy and access to existing services. (iii) it has maintained separation between towns. (iv) it has retained valuable agricultural land and

other space-extensive uses. (v) it has retained accessible land in pleasant surroundings nearer to people in inner cities than would otherwise have been the case. (vi) it can be used to assist urban regeneration.

Korean housing market has been known for its unique tenure system. Most housing market studies were concentrated on demand side analysis and determination of tenure system. Follain et al. (1980, 1982), Lim et al. (1980, 1984), and Renaud (1988, 1989) reported the situations of Korean housing markets and explained the Chonsei system as an efficient response to the financial depression. Also Kim (1990) argued that the inadequate mortgage financing system in Korea leads to the market inefficiency. Due to long standing policies of exports it is widely known that the housing sector has been equipped with less than optimal level of capital. Kim and Suh (1991) tried to answer whether the investment in the housing sector has been suboptimal. They found the allocation of capital between the housing and non-housing sector is not optimal by using 1970-1986 data.

Most studies about the Greenbelt restriction in Seoul concentrate on discussing the welfare loss because it has a pervasive effect on residential land and housing supply -- it physically restricts the residential land development and prevents constructing a new structure inside the Greenbelt area. However, if the Greenbelt has an amenity effect on the adjacent areas, the welfare loss could be exaggerated because the amenity effect improves the environmental surroundings in the adjacent areas and this improvement will be capitalized into the land value and housing price.

Amenity effects will be capitalized in the long run because people tend to put more weight on environmental quality. In a typical urbanization process, population is concentrated in the central area at earlier stages and dispersed outward and concentrated in suburbs later. Population concentration will induce more demand for land and housing so that it increases the land and housing prices. Population dispersion can be accelerated

by the amenity effect of the Greenbelt because people will demand a better environment after enjoying higher incomes. Therefore, the Greenbelt increases the land and housing prices by both the physical restriction and the amenity effect but not by the physical restriction alone as assumed in most studies.

Suh (1987) theoretically showed that the Greenbelt induces population concentration around the Greenbelt if the land demand is close to a linear. In the long run more people live near the Greenbelt, and total population in urban area increases. This is quite opposite effect of the Greenbelt because it is designed to check the population growth. Suh concluded that the Greenbelt is not proper to check the urban population in the long run if the demand for land is almost linear. Kim (1987) considered the social gain from releasing the Greenbelt regulation based on the proposition that the physical restriction affects the housing and land prices in Seoul, but he excluded the possibility of the amenity effect. The physical restriction and amenity effect work in an opposite direction on the welfare consequences of the Greenbelt. Choi (1993) estimated the land rent gradient in the metropolitan Seoul area by using simple semi-log functional form. He concluded that the simple descriptive model of rent gradient estimation is inferior to the behavioral model with time analysis.

Most amenity studies have dealt with crime, air pollution, school expenditure, neighborhood zoning and for the U.S., non-white population. For air pollution, specific variables are used for estimating the marginal benefit from the amenity effect. Harrison and Rubinfeld (1978) used NO_2 (nitrogen dioxides) and particles. A new concept of amenity value measurement was developed by Smith (1978), an amenity premium.

There were several papers in which general variables were used for amenity estimation. Correll et al. (1978) and Nelson (1988) used general variables to estimate the amenity effect. The former analyzed the Greenbelt effect on residential property in Boulder, Colorado. They found that the property value decreases by $4.2 per foot for

every foot one moves away from the Greenbelt. Nelson analyzed the amenity influence on land value in Portland, Oregon. By using 1983-1986 data, he found there were 4% ($7300 per acre) decreases in land value when one moves away from the Growth boundary by 100 feet.

We will use similar general variables for estimating the amenity effect of the Greenbelt in Seoul. When one moves away from the Greenbelt, the land rent will decrease because one enjoys less amenity.

Chapter II

II. Theoretical Analysis of the Effect of the Greenbelt

We look at the basic urban economic theory and adjust it to the case with the Greenbelt to investigate the effects of Greenbelt. Thanks to the works of Alonso (1964), Mills (1967) and Muth (1969), urban economics has a strong theoretical foundation. While Alonso assumed individuals consume land directly, Mills and Muth used a different presumption that land is only an intermediate input in the production of housing, and an individual consumes housing services as the final consumption good instead of components like land directly. Considering the differences in both traditions, we will use Alonso's model to explain the relationship between land price (or rent) and the amenity-related variables in the land market while we use the Mills-Muth model to analyze the amenity effect in the housing market.

1. Land Market

1-1. *Model without Amenity*

Our simple model is based on a monocentric city. Every household chooses its own residential location by maximizing the same utility function with the same income level since all households in urban area are homogeneous. They consume x of composite good and z of land. Also they commute to work to the central business district (CBD) and pay $t(k)$ of transportation cost. The price of a composite good is a numeraire and the

price of land, *r(k)*, varies with the distance, *k*, from the CBD, that is located at the center of urban area.

The household's problem of choosing a residential location can be expressed,

$$(1) \quad \underset{x,z,k}{Max}\ U = U(x, z)$$

$$s.t.\ \ y = x + r(k)z + t(k).$$

From the first order condition, we can get the well-known results,

$$(2\text{-}1) \quad U_x/U_z = 1/r(k)$$

$$(2\text{-}2) \quad r_k z = -\ t_k$$

Condition (2-1) illustrates the marginal rate of substitution between x and z is equal to the relative prices. Condition (2-2) shows that when a household moves farther to the CBD, it pays less rent ($r_k<0$) and more transportation cost ($t_k>0$). When a household moves farther from the CBD, it faces a trade-off between the transportation cost and the rental payment since it must satisfy the budget constraint. This is called as Muth's condition that the marginal transportation cost is equal to the marginal land cost saving. Therefore we have a downward sloping equilibrium rent schedule with respect to the distance from the CBD which is shown as R_1 and R_2 in <Figure 3-(b)>. Two points need to be discussed in detail; (i) the convexity of the rent schedule and (ii) the relationship between the market rent schedule *r(k)* and the household bid rent schedule $R_i(k)$.

The equilibrium rent schedule or bid rent curve need not always be convex as depicted in the figure. Convexity depends on the shape of transportation cost function, *t(k)*. We may use the indirect utility function of

$$(2') \qquad v(r,\ y\text{-}t(k)) = \max_{x,z}\{U(x,\ z)|I = y\text{-}t(k)\}$$

to find conditions for the convex rent schedule. Define the bid rent function of a household i as $R_i = R_i(k, U^*)$ or more formally,

$$(2'') \qquad R_i = \max_{z}\ \{\ (y_i\text{-}t(k)\text{-}x)/z \mid U(.)=U^*\}.$$

Then we have $\partial^2 R_i(k,\ U_i)/\partial k^2 = -[t_{kk}/Z_i(k,\ U_i)]+[t_k/Z_i(k,\ U_i)^2]\cdot[\partial Z_i(k,\ U_i)/\partial k]$ where $Z_i(k,\ U_i)$ is defined as a bid-max lot size. This bid-max lot size is related to the bid rent, R_i at equilibrium point of $U=U^*$. Tangency of utility and budget constraint at equilibrium implies that $-\partial x(z,\ U^*)/\partial z = \{y\text{-}t(k)\text{-}x(z,\ U^*)\}/z$. Solving this with respect to z gives us bid-max lot size Z_i, and $-\partial x(z,\ U^*)/\partial z = R_i(k,\ U^*)$. The bid rent is the maximum rent that the household can pay for residing at distance k and enjoy a fixed utility U^* while the bid-max lot size is the land demand corresponding to the bid rent. From expenditure minimization problem the bid-max lot size is equal to the Hicksian demand for land $z^c_i(R_i(k,\ U^*),\ U^*)$. Now we know that $t_k > 0$, and $\partial Z_i(k,\ U_i)/\partial k > 0$ since the following holds;

$$\partial Z_i(k,\ U_i)/\partial k = [\partial z^c_i(R_i(k,\ U^*),\ U^*)/\partial R_i][\partial R_i(k, U^*)/\partial k]$$
$$= -[\partial z^c_i(R_i(k,\ U^*),\ U^*)/\partial R_i][t_k/Z(k, U^*)] > 0.$$

Hence if $t_{kk} \leq 0$, then $\partial^2 R_i(k,\ U_i)/\partial k^2 > 0$. A linear or concave transportation cost function means the marginal transportation cost is nonincreasing; it is commonly observed case (see Fujita, 1989, p.22). The convexity of rent gradient needs a linear or concave transportation cost function.

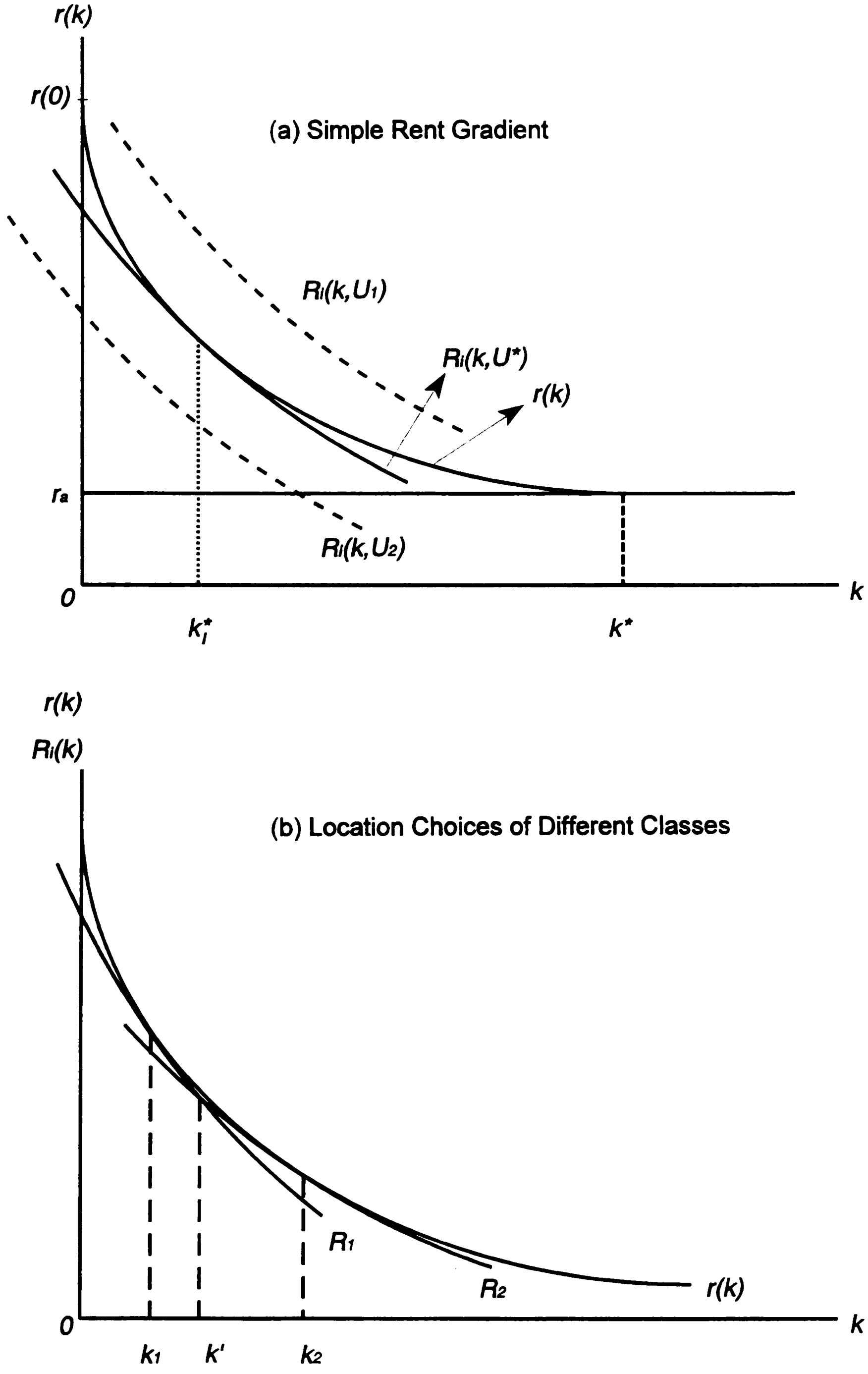
In <Figure 3-(a)> k^*_i is the optimal location that gives the household i the maximum utility U^*. If the household i has a higher bid rent than the market rent, it can increase its utility level by paying less for rent and purchasing more composite good x (in case of U_1). If the household i has a lower bid rent than the market rent, its utility level is less than optimum due to more rent payment and less consumption of the composite good x (in case of U_2). Hence in equilibrium the household bid rent $R_i(k)$ must be equal to the market rent $r(k)$. At optimal location of k^*_i, $U^* = v(R_i(k^*_i), y\text{-}t(k^*_i))$, $r(k^*_i)=R_i(k^*_i)$ and $U^* \geq v(R_i(k), y\text{-}t(k))\ \forall\ k \neq k^*_i$. Because the indirect utility function decreases in r and R_i, and increases in $y\text{-}t(k)$, $r(k) \geq R_i(k)\ \forall\ k$. If the convexity of bid rent and market rent does not hold, we have a corner solution rather than tangent solution.

The rent gradient in <Figure 3-(a)> can be interpreted as a market equilibrium rent curve. Each point corresponds to the chosen equilibrium location of a household and this household can't get the same utility at other locations since it enjoys the highest utility level at equilibrium. For the optimal location of k^*, we find that $r(k^*) = R_i(k^*, U^*)$, $r(k) > R_i(k, U^*)\ \forall\ k \neq k^*$. For Muth's condition, we have $r_{k^*} = R_{k^*} = -\ t_{k^*}/z$ at the optimal location. If $y_1 < y_2$, the net income of household 1, $y_1\text{-}t(k)$ is smaller than that of household 2, $y_2\text{-}t(k)$ and R_1 and R_2 intersect as shown in <Figure 3-(b)>. If land is a normal good, then the following relation holds at an intersected location, k' where $R_1=R_2=R'$, that is, $Z_1(k', U_1)=z(R', y_1\text{-}t(k')) < z(R', y_2\text{-}t(k'))=Z_2(k', U_2)$ where $z(.)$ is ordinary demand for land. When we apply the envelope theorem to the definition of $R_i(k, U^*)$, we can have,

$$(3)\qquad -\partial R_1(k', U_1)/\partial k = t_k(k')/Z_1(k', U_1) > t_k(k')/Z_2(k', U_2) = -\partial R_2(k', U_2)/\partial k.$$

This illustrates a comparative static analysis of the effect of the income level on household location. Higher income households can pay more for both transportation and land, but lower income households cannot afford to pay more. Therefore, higher income

Figure 3. Rent Gradients



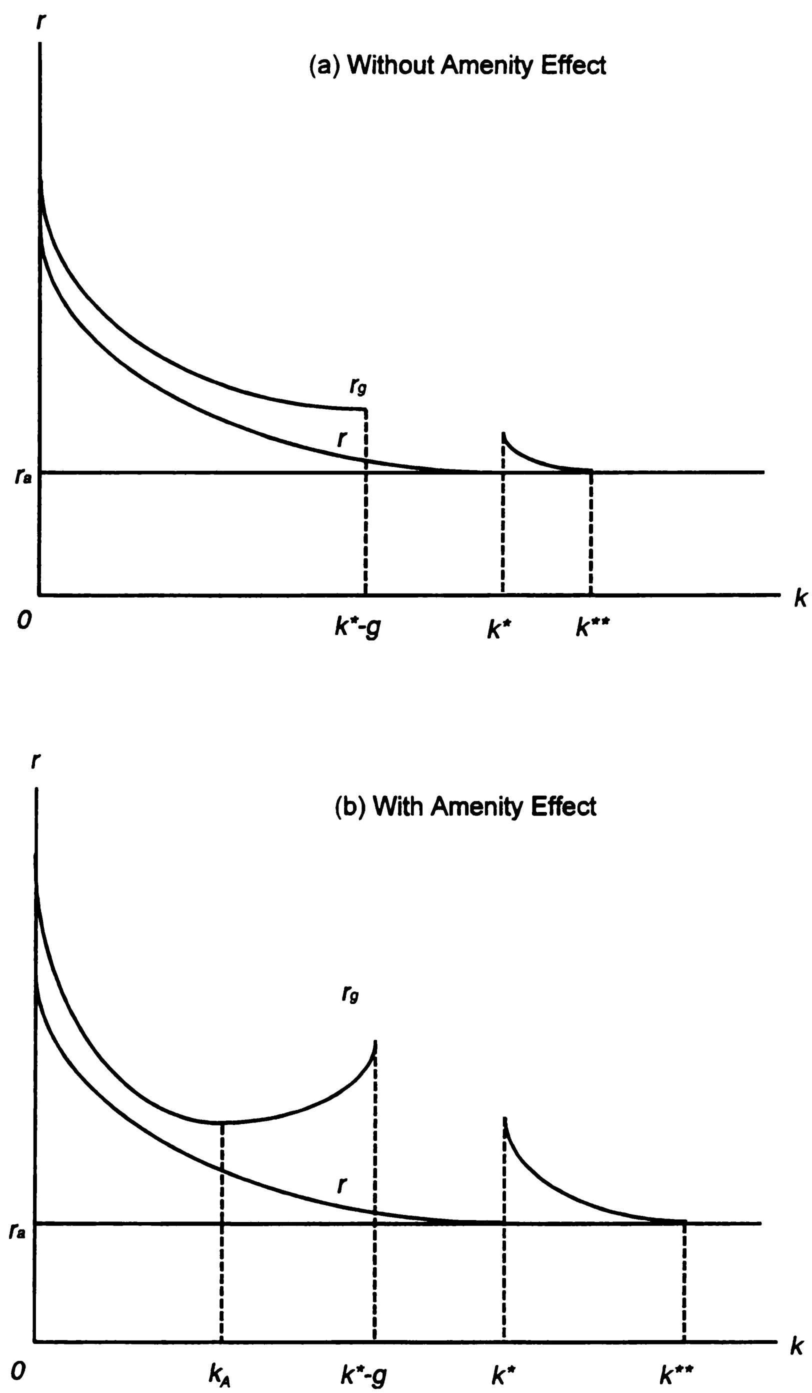
household has a flatter bid rent curve and locates farther from the CBD while the opposite is applied for lower income household.

1-2. *Model with Amenity*

The Greenbelt will confine the expansion of an urban area and consequently the residential land supply. Urban sprawl is easily seen in many large cities in the world including Seoul. As shown in < Figure 4-(a)>, suppose that the Greenbelt restriction is imposed with a width of g. A circular area with a width of g is not available for residential development. Physical shortage of urban land raises rent at every location except in the Greenbelt area that is assumed to receive an agricultural rent. Land conversion outside the outer boundary of the Greenbelt deepens the discontinuous development. Inside the inner boundary of the Greenbelt, more intensive development prevails due to the economizing of land use. This will be a short run adjustment of the rent gradient.

However, in the long run, urbanization proceeds with economic growth. With population increases, disamenities such as congestion, bad air, severe noise will prevail even when the urban area expands. Now the government sets a limiting boundary around the urban area to prevent further urban expansion. If the limiting boundary is the Greenbelt, then it may be attractive to some people who appreciate the amenity of better environment. The Greenbelt is not developed as parks so that people cannot directly enjoy them. Rather, the Greenbelt amenity can be identified as fresh air, quiet surroundings, scenic view, or even direct enjoyment for excursion or strolling. As seen in the simple model, high income classes prefer to live farther from the CBD while low income classes prefer to live closer to the CBD. Since the Greenbelt is usually imposed at the city boundary, most of the benefits from the amenity go to high income families

Figure 4. Rent Gradient with Greenbelt



rather than being distributed equally between high and low income classes. If the urban economy grows at a steady rate, rising income would make people put more weight on amenity and it will not be a luxury good but a normal good. Demand for amenity increases steadily in the long run and the rent gradient moves upward at the adjacent area to the Greenbelt as shown in <Figure 4-(b)> because the amenity is capitalized into the rental value of land in that area. Therefore, in the short run, the Greenbelt affects the physical supply of urban land and raises rents equally at every location while it raises the rent of the adjacent area relatively higher to the other area in the long run if the amenity effect exists.

Benefits of the amenity effect from the Greenbelt are not distributed equally. Without the amenity effect, landlords inside the inner boundary of the Greenbelt may neither win nor lose since they receive higher rent and pay more development costs because high density development induces higher average costs of building per area. With the amenity effect, only landlords in the adjacent area of the Greenbelt may enjoy more benefit. If a rental payment is defined as a monthly payment of tenants to landlords, tenants neither lose nor win since their rental payments now increase by the amenity benefit which they enjoy. Higher rent comes from higher land value and higher building costs.

At locations too far from the Greenbelt the amenity effect is close to zero. Land located far inside the inner boundary of the Greenbelt receives a usual urban rent. Land far outside of the Greenbelt outer boundary receives a mere agricultural rent. At locations with a positive amenity effect outside the Greenbelt outer boundary it may receive higher rent than the agricultural rent as urban development begins. Considering the dynamic nature of urban expansion, rent begins with the sum of the agricultural rent, the amenity benefit and the land conversion costs to urban use. As the urban area expands in the long run, the peripheral agricultural land is developed and converted into urban use. At

locations close to the Greenbelt outer boundary such a development cost is embodied into the land rent. What has been ignored is landlords inside the Greenbelt, and they are major losers under the Greenbelt restriction because they receive only agricultural rent even though the amenity effect is higher than in any other areas.

An amenity may be defined as a location-specific good. This definition implies that there is no usual market for the amenities. Consumption of amenities varies only through relocation. The right to live in an area with more amenities must be purchased in order to increase the consumption level of the amenities. Therefore, the property market is linked with amenity consumption. In other words, locational amenities affect such major determinants of household well-being as personal security and health, leisure time, housing quality, quality education and the opportunity set faced by the household for market consumption activities.

We can use a simple land market model and introduce some new variables. Let $I(k)$ be net income that is defined as $y - t(k)$ and let $A(k)$ be an amenity. The household will choose a residential location by following,

$$(4\text{-}1) \quad \underset{x,z,k}{Max}\ U(x, z, A(k)) \quad s.t.\ I(k) = x + r(k)z.$$

And the first order condition gives,

$$(4\text{-}2) \quad U_z/U_x = r(k),$$

$$(4\text{-}3) \quad U_A/U_x = \{r'(k)z - I'(k)\}/A'(k).$$

The equation (4-3) implies that a household will be in equilibrium only when the marginal value of the amenity equals the net increment of the two factors divided by the marginal change in amenity. Rearranging the equilibrium condition (4-3), we get,

(4-4) $r'(k) = (U_A/U_x)A'(k) + I'(k).$

As a household moves away from the CBD, commuting cost increases and income net of transportation cost decreases, $I'<0$. If the amenity is negligible at locations near the CBD, and the marginal utility of the amenity is negligible, the rent gradient is negative as in the simple model without amenity since the first term in the right hand side is negligible. Let k_A be a location which has a non-negligible amenity effect (see <Figure 4-(b)>). $r'(k)$ at $k \geq k_A$ can be positive depending on the relative magnitude of two terms in the right hand side of equilibrium condition. As one moves away from the CBD up to k_A, there is no amenity effect. If one resides at the locations of $k \geq k_A$, one can experience a positive amenity effect. The rent gradient is positive as the marginal increase of amenity is larger than the marginal decrease of net income. This could happen at the locations near the Greenbelt.

It brings a question about the shape of the $A(k)$ function. It might be a ∩-shape but not symmetric. <Figure 4-(b)> illustrates a possible shape of $A(k)$ function. After k_A, the slope of rent gradient is positive as one moves closer to the Greenbelt. We cannot say the exact shape of $A(k)$ because it is an empirical question.

2. Housing Market

Let us formalize the amenity effect in an urban system, following the Mills-Muth tradition for analyzing the housing market. Our system is a typical urban economy that contains the housing supply and demand in a closed city. A closed city model is based on the assumption that population size is fixed so that there is neither migration nor immigration -- in this sense, our model is a short run model. The basic model is expressed from (5) to (12) below.

$$(5) \quad h_D(k) = B\cdot(y-tk)^{\eta}p(k)^{\varepsilon}A(k)^{\rho}$$

$$(6) \quad h_D(k)\{dp(k)/dk\} = -t$$

$$(7) \quad h_S(k) = C\cdot L(k)^{\alpha}K(k)^{1-\alpha}$$

$$(8) \quad \alpha p(k)h_S(k)/L(k) = r(k)$$

$$(9) \quad (1-\alpha)p(k)h_S(k)/K(k) = i$$

$$(10) \quad n(k)h_D(k) = h_S(k)$$

$$(11) \quad L(k) = \phi k\ ;\ 0 \leq \phi \leq 2\pi$$

$$(12) \quad \int_0^{k^*} n(k)dk = M.$$

Housing demand is defined as (5). It depends on income (net-of-transportation-cost income and the transportation cost is assumed to be linear in k), price and amenity. This setting of housing demand can be treated as an effective demand for housing. Housing demand (5) can be rewritten as follows,

$$(5\text{-}1) \quad h^e(k) = B\cdot(y-tk)^{\eta}p(k)^{\varepsilon}\cdot f(A(k)).$$

The last term, $f(A(k))$ converts the usual housing demand to effective demand by normalizing the housing demand to be 1. Equilibrium must satisfy Muth's condition of (6). The supply function is represented as a Cobb-Douglas technology and depends on two input factors of land and capital as shown in (7). We assume that there is only one supplier in a circular area at each k km from the CBD and each supplier competes with other neighboring suppliers. Each supplier must satisfy the zero profit and cost minimization conditions that are explained by (8) and (9). $r(k)$ and i are prices of land and capital and are assumed to be given exogenously to the suppliers. Housing demand

of each household in the housing market determines equilibrium rent gradient, $r(k)$ in the land market.

In equilibrium, the total housing supply must be equal to the total housing demand. In each circular area, we have $n(k)$ households and (10) shows the housing market clearing condition. In each circular area in a city, the amount of land for housing is given as (11). Total population is fixed as explained above and shown in (12). We assume that a household is composed of one man and the number of households is equal to the population in a city.

From (8) and (9), we have the usual result of a constant returns technology as follows,

$$(13) \quad p(k)h_S(k) = r(k)L(k) + iK(k).$$

Arranging (8) and putting the result into (9), we can get,

$$(14) \quad K(k)/L(k) = (1\text{-}\alpha)r(k)/\alpha i.$$

In equilibrium suppliers employ two factors until the marginal product of each input equals to its price. Equation (14) is the optimal ratio of two factors employed. Substituting (14) and (7) into (13) and arranging the result, we have the following equilibrium housing price expressed by factor prices,

$$(15) \quad p(k) = D\cdot r(k)^{\alpha} i^{1\text{-}\alpha} \quad where\ D = \{C\cdot(1\text{-}\alpha)^{1\text{-}\alpha}\alpha^{\alpha}\}^{\text{-}1}.$$

Differentiating this with respect to k,

$$(16) \quad dp(k)/dk = \alpha D \cdot \{r(k)/i\}^{\alpha - 1}\{dr(k)/dk\}.$$

Substituting (15) into (5) and putting this result and (16) into (6), we have,

$$(17) \quad E \cdot (y-tk)^{\eta} r(k)^{\beta - 1} A(k)^{\rho}\{dr(k)/dk\} + t = 0$$

where $E = \alpha B \cdot D^{\varepsilon+1} i^{(1-\alpha)(\varepsilon+1)}$ and $\beta = \alpha(\varepsilon+1)$.

It is another version of Muth's condition, that is, with given transportation cost and housing price each household decides where to live by satisfying Muth's condition. The solution of the differential equation (17) is given by,

$$(18) \quad r(k) = [F + \{t\beta E \cdot (y-tk)^{1-\eta} A(k)^{1-\rho}\}/\{(1-\rho)(y-tk) - t(1-\eta)A(k)\}]^{1/\beta}$$

$r(0) = \{F/(1-\rho)y\}^{1/\beta}$ if $A(0) = 0$.

where F is an integral constant.

This is an equilibrium rent schedule in the land market after satisfying the household's locational choice problem and suppliers' cost minimization problem. From (8), (11) and (15) we have,

$$(19) \quad h_S(k) = (\phi i^{\alpha-1}/\alpha D) \cdot k r(k)^{1-\alpha}.$$

Substituting (5), (15) and (19) into (10), we can get

$$(20) \quad n(k) = G(y-tk)^{-\eta} A(k)^{-\rho} k r(k)^{1-\beta}$$

where $G = \phi B^{-1}[C(1-\alpha)^{1-\alpha}\alpha^{\{(\beta-1)/(1+\varepsilon)\}}]^{1+\varepsilon} \cdot i^{(\alpha-1)(1+\varepsilon)}$.

From the population size condition of (12), we can obtain the numerical solution of F by using the values of t, E, α, ϕ, η for given value of k^*. Finally, the solution of $p(k)$, by substituting (18) into (15), can be given as the following,

$$(21) \quad p(k) = D\cdot[F+\{t\beta E\cdot(y-tk)^{1-\eta}A(k)^{1-\rho}\}/ \{(1-\rho)(y-tk)-t(1-\eta)A(k)\}]^{\{1/(1+\varepsilon)\}}i^{1-\alpha}.$$

From (18) and (21), we see that the amenity effect, $A(k)$, is embodied into the land rent of $r(k)$ and the housing price of $p(k)$. Note that the slopes of land rent and housing price are not guaranteed to be negative everywhere any more because they depend on the signs and magnitudes of parameters such as ε, η and ρ.

If the housing demand is unitary elastic with respect to its price, that is, $\varepsilon = -1$, we may have a simpler solution. The differential equation of (17) is changed to be

$$(17') \quad \alpha B(y-tk)^{\eta}A(k)^{\rho}\cdot[dr(k)/dk]/r(k) + t = 0.$$

The corresponding land rent function which is the solution of (17-1), can be expressed as,

$$(18') \quad r(k) = \gamma\cdot exp[\{t(y-tk)^{1-\eta}A(k)^{1-\rho}\}/\{\alpha B(1-\rho)(y-tk)-t(1-\eta)A(k)\}].$$

We may have new $n(k) = (\phi/\alpha B)(y-tk)^{-\eta}A(k)^{-\rho}\cdot kr(k)$ and the population size condition is rewritten as,

$$(20') \quad \int[(\phi/\alpha B)(y-tk)^{-\eta}A(k)^{-\rho}\cdot kr(k)]dk = M.$$

As shown in (18) and (18'), the land demand function is derived from the housing demand (Muth-Mills' assumption). Strictly speaking, the simple land market model in section 1 has a different demand for land from the above two demand functions because the land demand in section 1 is assumed to be directly related with the consumers' utility (Alonso's assumption). Usually a parcel of land is consumed jointly with housing. In the line of empirical implications and consumers' behavior in the real world, it is plausible to say that a consumer demands housing services and the land demand is deduced from the housing services demand.

We have developed a simple model for explaining the amenity effect in the urban area. In Alonso's framework the amenity is introduced as an argument in the utility function. The slope of the rent gradient is not always negative when there is an amenity effect. After passing the point of k_A, the rent gradient might increase with the distance from the CBD. Whether it is negative or positive depends on the relative strength of the marginal amenity benefit and the marginal transportation cost. We can say that the amenity effect is capitalized into the land rent and prices, and if the amenity effect is strong, the slope of the rent gradient is positive near the Greenbelt. The Muth-Mill's framework shows a similar result. If the demand for the housing services is defined by three elements of the income, the housing price and the amenity, the amenity is shown to be capitalized into the housing prices and land rent. Both are based on the assumption of a single CBD. Whether following the Alonso's or Muth-Mill's line, the amenity effect of the Greenbelt truly affects housing consumption behavior by raising the land rent and housing prices up.

Chapter III

III. Empirical Analysis of the Amenity Effect

We now estimate the equilibrium rent schedule in (18). It contains a full information of the suppliers' and households' behavior as seen in the last chapter. It is shown to depend on the distance from the CBD and other parameters. For all the empirical estimation, we use distances from the central business district and the Greenbelt. The distance from the Greenbelt is used for measuring the amenity effect.

Land value and land rent are closely related to each other. Land rent is the price of the services yielded by land during a specific period while land value is the present value or discounted value of the rent. Therefore if a parcel of land yields a rent of r per year in perpetuity, the price of the land parcel, PV, can be expressed as following,

$$(22) \qquad PV = r/i.$$

Note that i is an appropriate interest rate used in discounting. When there are changes in land rent, they affect land value or land price.

Traditionally, land rent is a function of the distance from the CBD. So the general form of rent gradient function can be written as following,

$$(23) \qquad r = f(k).$$

As denoted before, k is the distance from the CBD. For estimating the rent gradient, the negative exponential form or semi-log form is widely used and its basic form is,

(24) $r = r_0 e^{-qk}$ or $ln(r) = ln(r_0) - qk$.

Spatial variations in land rents can be traced by the two statistics of r_0 and q. r_0 is the land rent at the center, $k=0$ while q shows the gradient or slope coefficient. In empirical work, the negative exponential form is popular since it is easy to interpret r_0 and q. Since we want to see the amenity effect of the Greenbelt, we include the distance from the Greenbelt boundary. Let k_1 and k_2 be the distances from the CBD and the Greenbelt respectively. The above equation can be rewritten as,

(25) $r = r_0 e^{-(q_1k_1+q_2k_2)}$ or $ln(r) = ln(r_0) - (q_1k_1 + q_2k_2)$.

This will be the basic equation to be estimated in our analysis of amenity effect in land market. Equation (24) and (25) are treated as a simple version of equilibrium rent gradient (18). Net-of-transportation-cost income, y-tk is replaced by k_1 while k_2 is used for the amenity effect, $A(k)$.

1. Data

The Korean government has a long tradition of collecting data on land values. Since the land price has been soaring up, it has made a strenuous effort to monitor land value. It is easy to get data but they are less than ideal; as mentioned earlier, several data systems are used by different institutions. We will use data sets released from the Korea Appraisal Board (KAB). They have been used for previous land value studies; Mills and Song (1979) and Kim (1987).

The land value data of the KAB are appraised primarily for the finance and accounting purposes in the private sector. Appraisals are done with the market

comparison method. There is no systematic evidence on how closely these appraised land values approximate market values, but they are closer to sale prices than rental values. The KAB seems to underestimate market values to provide a buffer for financial institutions to offset the risk of loan default. It is generally believed that this buffer is around 30%, and that the appraised values are about 70% of the market values on average. Such an underestimation affects our welfare calculation because estimated welfare benefit may be less than the true benefit. Our estimation might be biased upward and exaggerate the true relationships if the market comparison method is based on comparing each parcel according to the distance to the CBD and the Greenbelt.

Data are composed of each dong and category. A dong is the smallest unit for legal and administrative purposes, and the categories contain 12 different values according to the land use and quality. There are about 500 administrative dongs in Seoul, and the average area of a dong is 1.2 km^2. We will use the residential use category in the selected years of 1975, 1980, 1984 and 1989. In each year we have three classes of quality, and they are residential-high quality, residential-medium quality and residential-low quality. It is not clear what systematic criteria the KAB has used for quality differences. Descriptive statistics of data are reported in <Table 2>.

<Table 2> Descriptive Statistics of Data

Variables	DISGB	DISCBD	V75RH	V75RM	V75RL
N	426	426	390	351	318
Minimum	0.000	0.010	10.000	7.000	5.000
Maximum	6.400	17.600	350.000	250.000	200.000
Mean	3.231	5.547	131.077	88.598	44.387
Variance	3.101	20.164	6349.351	3143.618	1384.717
Median	3.700	4.200	110.000	70.000	30.000
Standard Deviation	1.761	4.490	79.683	56.068	37.212
Variables	**V80RH**	**V80RM**	**V80RL**	**V84RH**	**V84RM**
N	376	312	269	354	272
Minimum	70.000	30.000	15.000	60.000	30.000
Maximum	800.000	700.000	450.000	480.000	390.000
Mean	511.609	353.654	219.647	275.475	197.415
Variance	36263.471	17697.217	8249.035	7177.950	2985.498
Median	500.000	350.000	250.000	270.000	197.000
Standard Deviation	190.430	133.031	90.824	84.723	54.640
Variables	**V84RL**	**V89RH**	**V89RM**	**V89RL**	
N	240	331	236	189	
Minimum	11.000	242.000	151.000	151.000	
Maximum	300.000	1050.000	756.000	605.000	
Mean	148.300	546.810	430.441	333.217	
Variance	2080.805	19123.900	8971.677	6521.022	
Median	150.000	514.000	423.000	302.000	
Standard Deviation	45.616	138.289	94.719	80.753	

Note ; DISGB -- distance from the Greenbelt (*km*)
DISCBD -- distance from the CBD (*km*)
RH -- residential high quality (*'000 won*)
RM -- residential medium quality (*'000 won*)
RL -- residential low quality (*'000 won*)

* Land value in 1975 and 1980 is per *pyong* and in 1984 and 1989 is per m^2.

2. Empirical Model

We used a linear spline function because there is no prior information about the functional form of rent gradient. Spline functions are a device for approximating the shape of a curvilinear stochastic function without the necessity of pre-specifying the mathematical form of the function. If the scatter of observations shows that a linear estimation would be a poor fit, and it is uncertain that any polynomials would improve the fit, then one can apply a series of linear regressions to each segment. Let the desired relationship of a piecewise regression be as,

$$(26) \quad r = [a_1+b_1(x-x_0)]d_1 + [a_2+b_2(x-x_1)]d_2 + [a_3+b_3(x-x_2)]d_3 + u$$

where u is an error term and $d_i = 1$ if $x_{i-1} \leq x < x_i$, $= 0$ otherwise.

Scatter of observations are approximated by three linear regressions over three intervals which are divided by x_1 and x_2. These intervals are called as knots. The regression needs restrictions to avoid the discontinuity at x_1 and x_2. Required restrictions are as follows,

$$(27) \quad a_2 = a_1 + b_1(x_1-x_0)$$
$$a_3 = a_2 + b_2(x_2-x_1).$$

Inserting (27) into (26), the piecewise linear regression of (26) can be rewritten as follows,

$$(28) \quad r = a_1 + b_1[(x-x_0)d_1+(x_1-x_0)d_2+(x_2-x_1)d_3]$$
$$+ b_2[(x-x_1)d_2+(x_2-x_1)d_3] + b_3[(x-x_2)d_3] + u.$$

The above linear spline is our basic funtion for estimating the rent gradient. Piecewise linear approximation of (26) is converted into a multiple regression of (28).

The linear spline function is not free from shortcomings. The estimated function is continuous at knots because some restrictions are imposed on the functional form. But its derivatives are not continuous. This might be a serious disadvantage in many economic applications where the result would be expressed as elasticities and marginals. Also the knots which give intervals in estimation are arbitrarily chosen. These disadvantages are overcome by a cubic spline function, but it is not easy to interpret the estimated results because it is cubic. The estimated results of linear spline function is easily interpreted. Furthermore, it may give a robust estimation.

We use the distances from the CBD and the Greenbelt as independent variables, and they are denoted as x and y respectively in the estimation. Each estimation needs transformed composite independent variables which are found in bracket of (28). These transformed composite variables are denoted by subscript i, and i is a knot to decide the intervals in each estimation.

< Table 3 >
Definition of Variables used in Spline Estimation

Variables used in Spline Estimation	Description of Variables	Corresponding coefficients
x	distance from the CBD	β_1
x_5	transformed x at x=5	β_2
x_{10}	transformed x at x=10	β_3
y	distance from the Greenbelt	β_4
y_1	transformed y at y=1	β_5
y_2	transformed y at y=2	β_6
$y_{3.5}$	transformed y at y=3.5	β_7

3. Rent Gradient Estimation

If we can identify a proper interest rate, we can calculate the land rent by using the equation (22) -- $PV = r/i$. As noted above, the formal financial market has worked for the export or export-related sectors, and for the land and housing market the informal financial market had to substitute for a repressed and controlled formal financial market. Many studies on the Korean housing market used the curb market rate for a proper interest rate or discount rate since it is widely agreed that it represents the opportunity cost of capital in the housing market.

We use the corporate bond yield rate, however, as a proper interest rate in the land market. Even though land is consumed jointly with a housing unit, it is different from housing. It is not only one of several inputs to housing production but also an investment good: Land is one of the most popular investment goods such as equity and corporate bonds in Korea. In this sense, the corporate bond yield rate is proper as an opportunity cost of capital in the land market. The nominal corporate bond yield rate is 20.1%, 30.1%, 14.1% and 15.2% in 1975, 1980, 1984 and 1989. Actually these numbers are not much different from the curb market rates in the corresponding years. Also, we implicitly assume that the land value is the present value of land rent over infinite time period.

Linear spline estimation is done with different settings of knots. First, we use 5, 10 *km* knots for the distance from the CBD and 1, 2, 3.5 *km* from the Greenbelt. Estimated results are reported in <Table 4-(a), (b), (c) >.

Residential high quality shows the highest fit among three of the estimated categories, and R^2 decreases for all residential qualities. For residential high quality it decreases from 0.843 in 1975 to 0.116 in 1989. Decreasing R^2 over the estimated period might be due to (i) emergence of the secondary urban centers in Seoul, (ii) enhanced public transport system and increasing car ownership, or (iii) techniques of collecting and

generating data have improved, and results of R^2 over the estimated period show this improvement of random response of the data.

Estimated coefficients show that the rent gradient has been flatter over the estimated period except for the residential low quality. For residential high quality, coefficients of the distance from the CBD change from -0.24, 0.166, -0.116 in 1975 to -0.051, 0.066, -0.041 in 1989. Those of the distance from the Greenbelt show a similar trend over the estimated period to the distance from the CBD. Most coefficients of the CBD distance variables are significant while those of the Greenbelt distance variables are not significant. It is due to land price hikes and severe speculation in Seoul area. Dramatic land price increases happened roughly once in 10 years and were higher than inflation rate.

Estimated slope of the rent gradient of residential high quality increases near the Greenbelt boundary and decreases at location of 1 or 2 *km* from the Greenbelt; in 1975 and 1989 the Greenbelt distance variables are shown in <Table 4> to be -0.368 and -0.213 respectively while -0.239 and -0.092 in 1980 and 1984. This result says that the maximum rent location moved from 1 *km* to 2 *km* in 1980 and returned to 1 *km* in 1989. In case of residential low quality the maximum rent location was 2 *km* during 1975-1984 and 1 *km* in 1989. It was 1 *km* in 1975, 1980, 2 *km* in 1984 and 1 *km* in 1989 for residential medium quality.

< Table 4 > Linear Spline Estimation I of Rent Gradient ; using all knots

(a) Residential High Quality

Dependent Variable	Natural Log of High Quality Land Rent			
	1975	1980	1984	1989
constant	3.934*	5.334*	4.492*	4.975*
x	-0.24* (-17.092)	-0.116* (-9.23)	-0.110* (-8.69)	-0.051* (-3.91)
x_5	0.166* (6.714)	0.078* (3.683)	0.127* (6.055)	0.066* (3.202)
x_{10}	-0.116* (-4.642)	-0.075* (-3.671)	-0.091* (-4.490)	-0.041** (-2.12)
y	0.318* (3.259)	0.117 (1.423)	0.051 (0.639)	0.175** (2.257)
y_1	-0.368** (-2.131)	0.090 (0.622)	0.038 (0.269)	-0.213 (-1.588)
y_2	0.033 (0.301)	-0.239* (-2.609)	-0.092 (-1.037)	0.043 (0.513)
$y_{3.5}$	-0.016 (-0.936)	-0.030** (-2.033)	-0.033** (-2.343)	-0.008 (-0.56)
adjusted R^2	0.843	0.713	0.435	0.116
N	390	376	354	331

Note ; 1) ( ) is t-value.
2) * is significant at 99%, and ** is significant at 95%.

- Hypothesis Test Results ; F-statistics

Hypothesis	**1975**	**1980**	**1984**	**1989**
$\beta_2=\beta_3=0$	22.57[a]	7.931[a]	18.413[a]	5.132[a]
$\beta_5=\beta_6=\beta_7=0$	6.967[a]	17.746[a]	7.548[a]	2.306
$\beta_2=\beta_3=\beta_5=\beta_6=\beta_7=0$	15.463[a]	16.818[a]	13.055[a]	3.881[a]

Note : **a** denotes that a null hypothesis is rejected at 99%, while **b** indicates that a null hypothesis is rejected at 95%.

(b) Residential Medium Quality

Dependent Variable	Natural Log of Medium Quality Land Rent			
	1975	1980	1984	1989
constant	3.583*	4.827*	3.911*	4.486*
x	-0.230* (-13.455)	-0.097* (-4.616)	-0.057* (-2.959)	-0.002 (-0.109)
x_5	0.140* (4.773)	0.069** (2.117)	0.085* (3.046)	0.030 (1.223)
x_{10}	-0.105* (-3.447)	-0.101* (-3.518)	-0.119* (-5.182)	-0.043** (-2.141)
y	0.174 (1.456)	0.214 (1.845)	0.042 (0.457)	0.136 (1.525)
y_1	-0.115 (-0.563)	-0.038 (-0.188)	0.179 (1.101)	-0.124 (-0.824)
y_2	-0.078 (-0.613)	-0.175 (-1.353)	-0.258** (-2.444)	0.012 (0.128)
$y_{3.5}$	-0.021 (-1.035)	-0.033 (-1.518)	0.002 (0.13)	-0.007 (-0.491)
adjusted R^2	0.803	0.595	0.345	0.032
N	351	312	272	236

Note ; 1) ( ) is t-value.
2) * is significant at 99%, and ** is significant at 95%.

- Hypothesis Test Results ; F-statistics

Hypothesis	1975	1980	1984	1989
$\beta_2=\beta_3=0$	11.398^a	6.266^a	13.506^a	2.297
$\beta_5=\beta_6=\beta_7=0$	4.131^a	8.482^a	5.164^a	1.113
$\beta_2=\beta_3=\beta_5=\beta_6=\beta_7=0$	8.135^a	10.692^a	11.373^a	2.116

Note : **a** denotes that a null hypothesis is rejected at 99%, while **b** indicates that a null hypothesis is rejected at 95%.

(c) Residential Low Quality

Dependent Variable	Natural Log of Low Quality Land Rent			
	1975	1980	1984	1989
constant	3.096*	4.248*	3.727*	4.055*
x	-0.259* (-10.834)	-0.055 (-1.855)	-0.089* (-3.757)	-0.024 (-1.356)
x_5	0.149* (3.885)	-0.014 (-0.297)	0.114* (3.058)	0.077* (2.889)
x_{10}	-0.109* (-3.129)	-0.066 (-1.535)	-0.148* (-3.989)	-0.065* (-2.593)
y	-0.010 (-0.069)	0.182 (1.092)	0.005 (0.034)	0.294* (2.806)
y_1	0.105 (0.436)	0.044 (0.155)	0.278 (1.13)	-0.227 (-1.329)
y_2	-0.005 (-0.032)	-0.233 (-1.295)	-0.331** (-2.154)	-0.015 (-0.147)
$y_{3.5}$	-0.048 (-1.783)	-0.034 (-1.121)	0.003 (0.118)	-0.029 (-1.761)
adjusted R^2	0.811	0.510	0.291	0.163
N	318	269	240	189

Note ; 1) ( ) is t-value.
2) * is significant at 99%, and ** is significant at 95%.

- Hypothesis Test Results ; F-statistics

Hypothesis	**1975**	**1980**	**1984**	**1989**
$\beta_2=\beta_3=0$	7.718[a]	2.791	8.173[a]	4.684[a]
$\beta_5=\beta_6=\beta_7=0$	1.602	4.933[a]	3.451[b]	6.85[a]
$\beta_2=\beta_3=\beta_5=\beta_6=\beta_7=0$	4.229[a]	6.361[a]	6.864[a]	6.961[a]

Note : **a** denotes that a null hypothesis is rejected at 99%, while **b** indicates that a null hypothesis is rejected at 95%.

In each table we provide results of hypothesis test about the spline specification. All results say that the spline specification is proper for estimating the rent gradient. These are reported in <Table 4> and <Table 5>. In most cases the null hypothesis is rejected at 99%.

Leaving the set of the CBD knots, for rent gradient II in <Table 5> we change the set of the Greenbelt knot to 1, 3.5 *km* in 1975 and 2, 3.5 *km* in 1980-1989. These estimated results are reported in <Table 5-(a),(b),(c) >. More of the Greenbelt distance variables are shown to be significant than those in previous estimation. R^2 shows a slight improvement. R^2 decreases over the estimated period; it falls from 0.844 in 1975 to 0.112 in 1989 for the residential high quality (same trend is found in other two quality categories).

Most estimated coefficients of the CBD and Greenbelt distance variables show patterns similar to those in the previous estimation. They have fallen over the estimated period. Coefficients of the CBD distance variables decrease from -0.24, 0.166, -0.116 in 1975 to -0.051, 0.069, -0.045 in 1989. Those of the Greenbelt distance variables fall; y and $y_{3.5}$ decrease from 0.301, -0.014 in 1975 to 0.061, -0.002 in 1989, and y_2 decreases from -0.191 in 1980 to -0.069 in 1989. The slope of rent gradient has been flat for the same reasons mentioned earlier. The rent gradient decreases around 2 *km* from the Greenbelt in 1975 and between 3 and 4 *km* from the Greenbelt in 1980-1989. Because the distance from the Greenbelt is assumed to measure the amenity effect, the estimated coefficients of the Greenbelt distance variables indirectly illustrate the existence of the amenity effect.

< Table 5 > Linear Spline Estimation II of Rent Gradient ; dropping some knots

(a) Residential High Quality

Dependent Variable	Natural Log of High Quality Land Rent			
	1975	1980	1984	1989
constant	3.937*	5.320*	4.479*	5.011*
x	-0.240* (-17.162)	-0.166* (-9.232)	-0.110* (-8.705)	-0.051* (-3.899)
x_5	0.166* (6.752)	0.077* (3.647)	0.126* (6.058)	0.069* (3.303)
x_{10}	-0.116* (-4.646)	-0.074* (-3.622)	-0.090* (-4.494)	-0.045** (-2.322)
y	0.301* (3.820)	0.164* (5.134)	0.071** (2.300)	0.061** (2.037)
y_1	-0.324* (-3.489)			
y_2		-0.191* (-3.891)	-0.072 (-1.511)	-0.069 (-1.504)
$y_{3.5}$	-0.014 (-0.921)	-0.032** (-2.258)	-0.034** (-2.491)	-0.002 (-0.165)
adjusted R^2	0.844	0.714	0.436	0.112
N	390	376	354	331

Note ; 1) ( ) is t-value.
2) * is significant at 99%, and ** is significant at 95%.

- Hypothesis Test Results ; F-statistics

Hypothesis	1975	1980	1984	1989
$\beta_2=\beta_3=0$	22.838[a]	7.759[a]	18.436[a]	5.46[a]
$\beta_5=\beta_7=0$ (1975) or $\beta_6=\beta_7=0$ (1980-1989)	10.43[a]	26.47[a]	11.315[a]	2.188
$\beta_2=\beta_3=\beta_5=\beta_7=0$ (1975) or $\beta_2=\beta_3=\beta_6=\beta_7=0$ (1980-1989)	19.352[a]	20.961[a]	16.344[a]	4.2[a]

Note : **a** denotes that a null hypothesis is rejected at 99%, while **b** indicates that a null hypothesis is rejected at 95%.

(b) Residential Medium Quality

Dependent Variable	Natural Log of Medium Quality Land Rent			
	1975	1980	1984	1989
constant	3.574*	4.833*	3.882*	4.513*
x	-0.229* (-13.453)	-0.097* (-4.623)	-0.057* (-2.951)	-0.002 (-0.112)
x_5	0.139* (4.758)	0.070** (2.137)	0.083* (3.003)	0.030 (1.258)
x_{10}	-0.106* (-3.481)	-0.102* (-3.592)	-0.117* (-5.117)	-0.043** (-2.16)
y	0.218** (2.249)	0.194* (4.285)	0.135* (3.819)	0.067** (2.165)
y_1	-0.220** (-1.956)			
y_2		-0.195* (-2.809)	-0.160* (-2.842)	-0.052 (-1.055)
$y_{3.5}$	-0.028 (-1.633)	-0.032 (-1.521)	-0.003 (-0.156)	-0.004 (-0.297)
adjusted R^2	0.803	0.596	0.345	0.034
N	351	312	272	236

Note ; 1) ( ) is t-value.
2) * is significant at 99%, and ** is significant at 95%.

- Hypothesis Test Results ; F-statistics

Hypothesis	**1975**	**1980**	**1984**	**1989**
$\beta_2=\beta_3=0$	11.334[a]	6.546[a]	13.166[a]	2.336
$\beta_5=\beta_7=0$ (1975) or $\beta_6=\beta_7=0$ (1980-1989)	6.02[a]	12.746[a]	7.134[a]	1.331
$\beta_2=\beta_3=\beta_5=\beta_7=0$ (1975) or $\beta_2=\beta_3=\beta_6=\beta_7=0$ (1980-1989)	10.093[a]	13.399[a]	13.902[a]	2.479[b]

Note : **a** denotes that a null hypothesis is rejected at 99%, while **b** indicates that a null hypothesis is rejected at 95%.

(c) Residential Low Quality

Dependent Variable	Natural Log of Low Quality Land Rent			
	1975	1980	1984	1989
constant	3.095*	4.239*	3.681*	4.116*
x	-0.259* (-10.852)	-0.055 (-1.854)	-0.089* (-3.744)	-0.025 (-1.361)
x_5	0.149* (3.892)	-0.015 (-0.321)	0.110* (2.963)	0.078* (2.915)
x_{10}	-0.109* (-3.138)	-0.064 (-1.541)	-0.143* (-3.876)	-0.065** (-2.57)
y	-0.007 (-0.062)	0.206* (3.187)	0.155* (2.765)	0.165* (4.254)
y_1	0.098 (0.75)			
y_2		-0.210** (-2.066)	-0.187** (-2.183)	-0.127** (-2.13)
$y_{3.5}$	-0.048** (-2.181)	-0.036 (-1.192)	-0.004 (-0.175)	-0.023 (-1.45)
adjusted R^2	0.812	0.512	0.290	0.160
N	318	269	240	189

Note ; 1) ( ) is t-value.
2) * is significant at 99%, and ** is significant at 95%.

- Hypothesis Test Results ; F-statistics

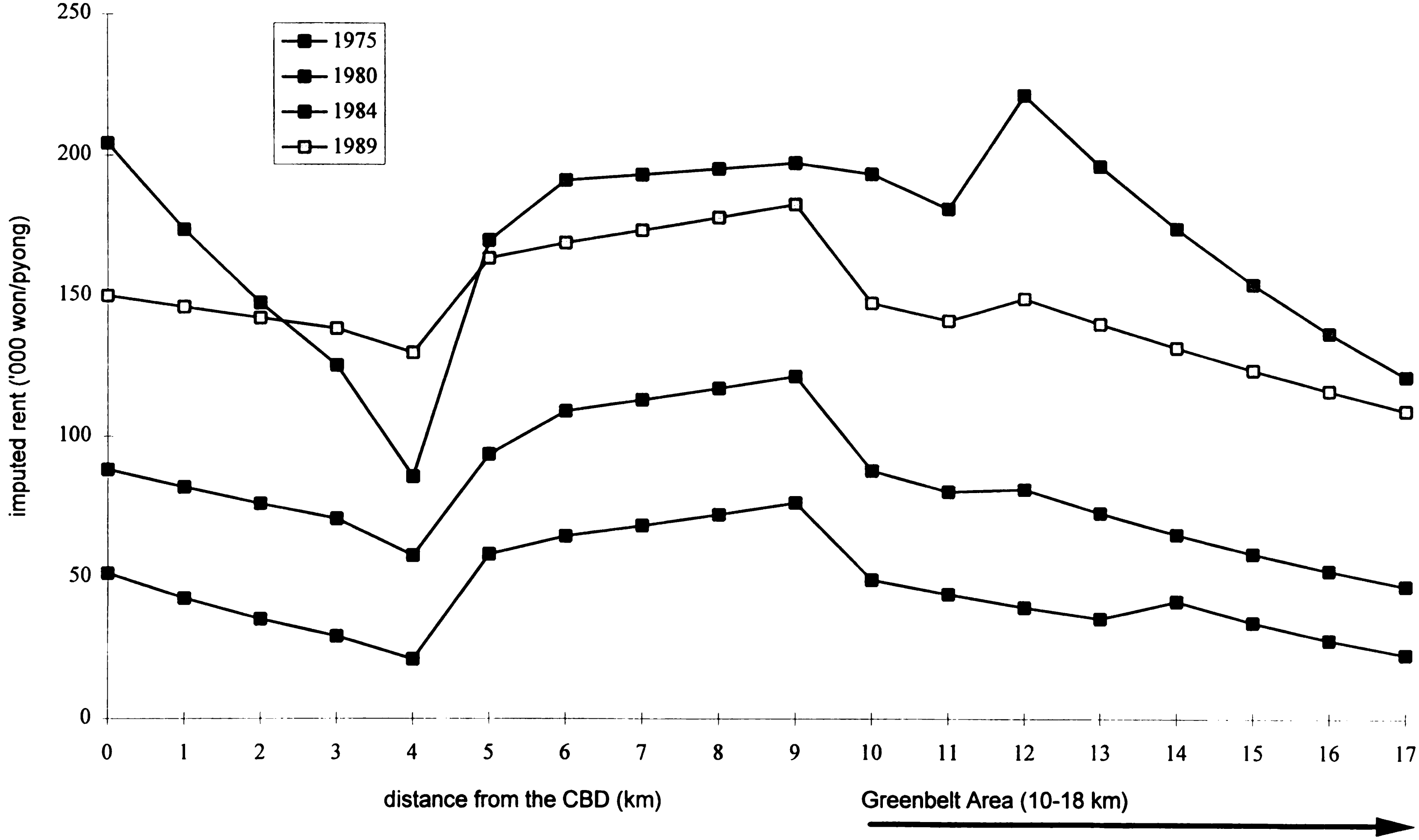
Hypothesis	**1975**	**1980**	**1984**	**1989**
$\beta_2=\beta_3=0$	7.47[a]	2.815	7.719[a]	4.708[a]
$\beta_5=\beta_7=0$ (1975) or $\beta_6=\beta_7=0$ (1980-1989)	2.41	7.415[a]	4.533[b]	9.353[a]
$\beta_2=\beta_3=\beta_5=\beta_7=0$ (1975) or $\beta_2=\beta_3=\beta_6=\beta_7=0$ (1980-1989)	5.303[a]	7.975[a]	8.251[a]	8.225[a]

Note : **a** denotes that a null hypothesis is rejected at 99%, while **b** indicates that a null hypothesis is rejected at 95%.

Besides the amenity effect of the Greenbelt, increasing car ownership makes possible for people to choose to live away from the CBD. Even though their marginal transportation cost increases as one moves away from the CBD, the total transportation cost does not increase dramatically due to decrease in travel time to work place. Also the public transport system such as subways makes commuting more convenient. These provide people for an opportunity to move away from the CBD without incurring much cost. As seen in <Figure 2-(b)>, population density in 1988 shows that the area between 13 *km* and 14 *km* from the CBD has the highest density. In the following section we estimate the population gradient.

We plot the estimated value of imputed rent over the distance from the CBD. It is shown in <Figure 2-(d)>. The Greenbelt starts at 10 - 18 *km* from the CBD. The estimated imputed rent in all years shows that it decreases as one moves away from the Greenbelt. This result partly comes from the knots we have chosen for linear spline estimation, and note that the knots chosen gave the best results.

Figure 2-(d). Fitted Value of Imputed Rent



4. Population Gradient

Population concentrates and disperses itself in urban areas during the process of urbanization. In urban economics, demographic studies have been carried out along with land and housing studies since the conditions in the land and housing markets are closely related to those demographic changes. Here, we apply the semi-log model to estimate the population gradient in Seoul. We use the population census data in 1975, 1980, 1985 and 1990. In each year, the population data are available in 225 dongs.

Estimated results are reported in <Table 6>. Overall fit is far from being significant, but coefficients are found to support the previous findings in rent gradient estimation. We carry out two different estimations; (i) includes the distances from both the CBD and the Greenbelt. (ii) includes only the distance from the Greenbelt.

Even though the overall fit is improved in the estimated period, R^2 is very low. Considering that it is a cross-sectional estimation, and that our prior concern is on the rent gradient, it is useful to explain the amenity effect and rent gradient. In case of (i), the distance from the CBD is more proper than the distance from the Greenbelt in explaining the population gradient. In case of (ii) the distance from the Greenbelt shows a poor fit but its coefficients are rather noticeable. It shows that the further from the Greenbelt, the less dense is the population. This might be expected partially because the amenity is not a critical factor for industrial locations. Industrial uses don't compete to locate close to the Greenbelt but rather they prefer to locate close to the CBD or other secondary centers. We have to be careful in conclusion because the residential area also decreases with the distance from the Greenbelt and the population density would give more precise insight for the population concentration.

< Table 6 > Population Gradient Estimation

Dependent Variable ; Natural Log of Population						
		Constant	*x*	*y*	*adjusted* R^2	*N*
(i)	1975	9.742*	0.036 (1.867)	0.037 (0.825)	0.01	198
	1980	9.544*	0.075* (4.006)	0.040 (0.919)	0.092	219
	1985	9.497*	0.099* (5.402)	0.024 (0.569)	0.186	223
	1990	9.283*	0.134* (6.987)	0.024 (0.543)	0.286	224
(ii)	1975	10.172*		-0.024 (-0.759)	0.000	198
	1980	10.443*		-0.085* (-2.740)	0.029	219
	1985	10.704*		-0.144* (-4.556)	0.082	223
	1990	10.897*		-0.200* (-5.901)	0.132	224

Note ; 1) ( ) is t-value.
2) * is significant at 99% and ** is significant at 95%.

Population increases along with the distance from the CBD in estimation (i). Degree of increasing population rises in the estimated period; from 0.036 in 1975 to 0.134 in 1989. Also population is found to increase with the distance from the Greenbelt, but its coefficients have been flat in the same peirod; 0.037 in 1975 to 0.024 in 1989. It means that population grows faster near the Greenbelt. Next, we drop the distance from the CBD. In estimation (ii) coefficients of the distance from the Greenbelt are found to increase in absolute terms; its absolute value increases from 0.024 in 1975 to 0.200 in

1989. It indicates that the slope of the population gradient near the Greenbelt is steeper in the estimated period.

We can build a possible scenario to explain changes in population and rent gradient in the estimated period. Economic growth puts more in everyone's pocket. Income increases enough to pay off increasing commuting cost as one lives away from the CBD, and/or people put more weight on the amenity since they prefer to live a better life in a descent environment. More people live near the Greenbelt than before, and the population density increases in this area. Increasing demand for land pushes land prices and rents up. Along with the amenity effect, the population pressure works in the same direction on land rent. The coincidence of the estimated results of population and land rent gradients might be closely related to the amenity effect of the Greenbelt.

Chapter IV

IV. Welfare Analysis of Releasing the Greenbelt Restriction

If there exists an amenity effect of the Greenbelt, then releasing the Greenbelt restriction does not necessarily increase everyone's welfare because some residents are worse off than before the land release due to lost amenity. We will calculate the social gain from the land release. If the lost amenity is higher than the gain from low rent at the one extreme, the social gain might be negative. We find that the amenity effect exists in the land market. Without considering the amenity effect, the social gain from the land release might be exaggerated.

1. Releasing Land from the Greenbelt

If a part or all of the total land in the Greenbelt is released from the restriction, land rent and housing prices will fall. Suppose that the government releases a δ km wide of land from the Greenbelt inner boundary. Now the city expands from k^* to $k^*+\delta$ while it must accomodate the same size of population, M as before. The total supply of urban land increases by

$$(29) \quad \int_{k^*}^{k^*+\delta} (\phi k)\, dk = \phi\delta(2k^*+\delta)/2 \quad \text{where } 0 \leq \phi \leq 2\pi.$$

The land supply increases by ϕ in each circular area at k *km* from the CBD where ϕ denotes the proportion of residential area in the total circular land area. Therefore the total land available for residential uses in each circular area is ϕk. The land rent will shift

everywhere since the intercept alone is affected while the other parameters are determined by preferences and technology (see <Figure 5-(a)>).

In a traditional theory of firms, a reduction of an input price lowers marginal cost and output increases by using the relatively cheaper input more intensively. In our model, total land supply is fixed in each location and the housing producer in each location k with $k < k^*$ will combine the same amount of land with a smaller amount of capital to produce less housing because the price of capital is expensive relatively to the price of land. The number of households, M, then adjusts spending to equate the total demand with the reduced supply in these locations and additional output of housing comes from the production on the released land with $k^* < k < k^*+\delta$.

The social gain, W, from the land release is composed of two parts. The first part is the value of the released land since the released land receives the urban land rent. If we assume that the released land has received zero land rent before the land release, we have,

$$(30) \qquad W_1 = \int_{k^*}^{k^*+\delta} \phi k \, r_N(k) \, dk$$

where $r_N(k)$ is a new land rent schedule after the land release, $r_N(k) = [F' + \{t\beta E(y-tk)^{1-\eta} A(k)^{1-\rho}\} / \{(1-\rho)(y-tk) - t(1-\eta)A(k)\}]^{1/\beta}$ (F' is a new intercept) and $r(k) > r_N(k)$.

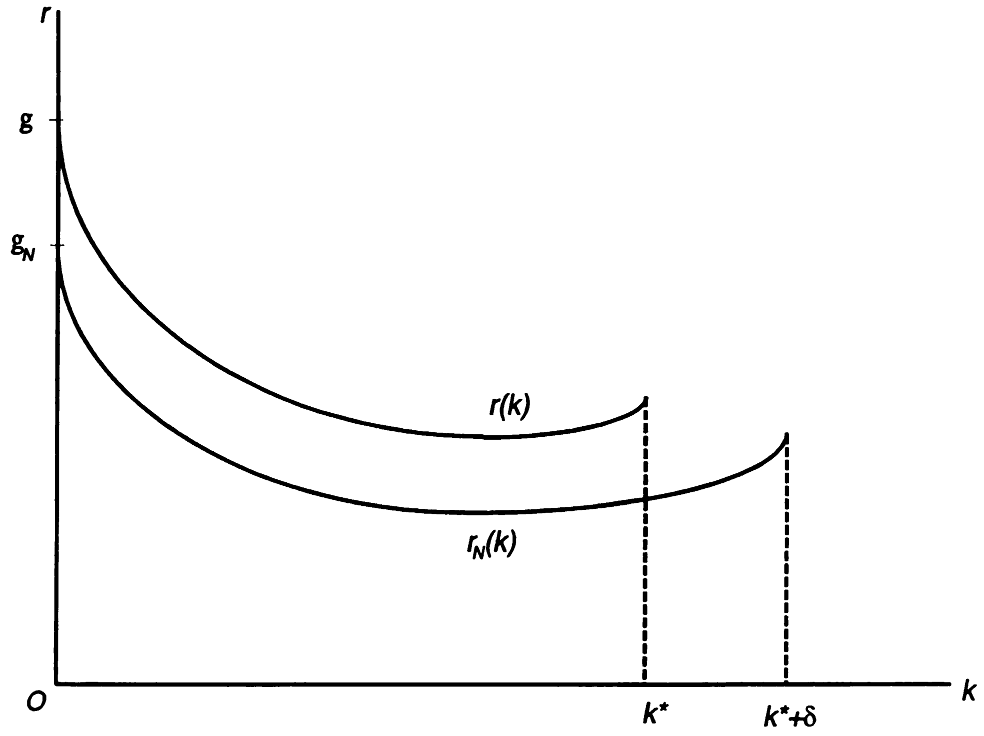
The second part is the money value of the utility gain from the housing price reduction and utility gain or loss from the amenity changes. This can be calculated by using the equivalent variation of each household at each location k. We have,

$$(31) \qquad W_2 = \int_{0}^{k^*} n(k)\omega(k)EV(k) \, dk$$

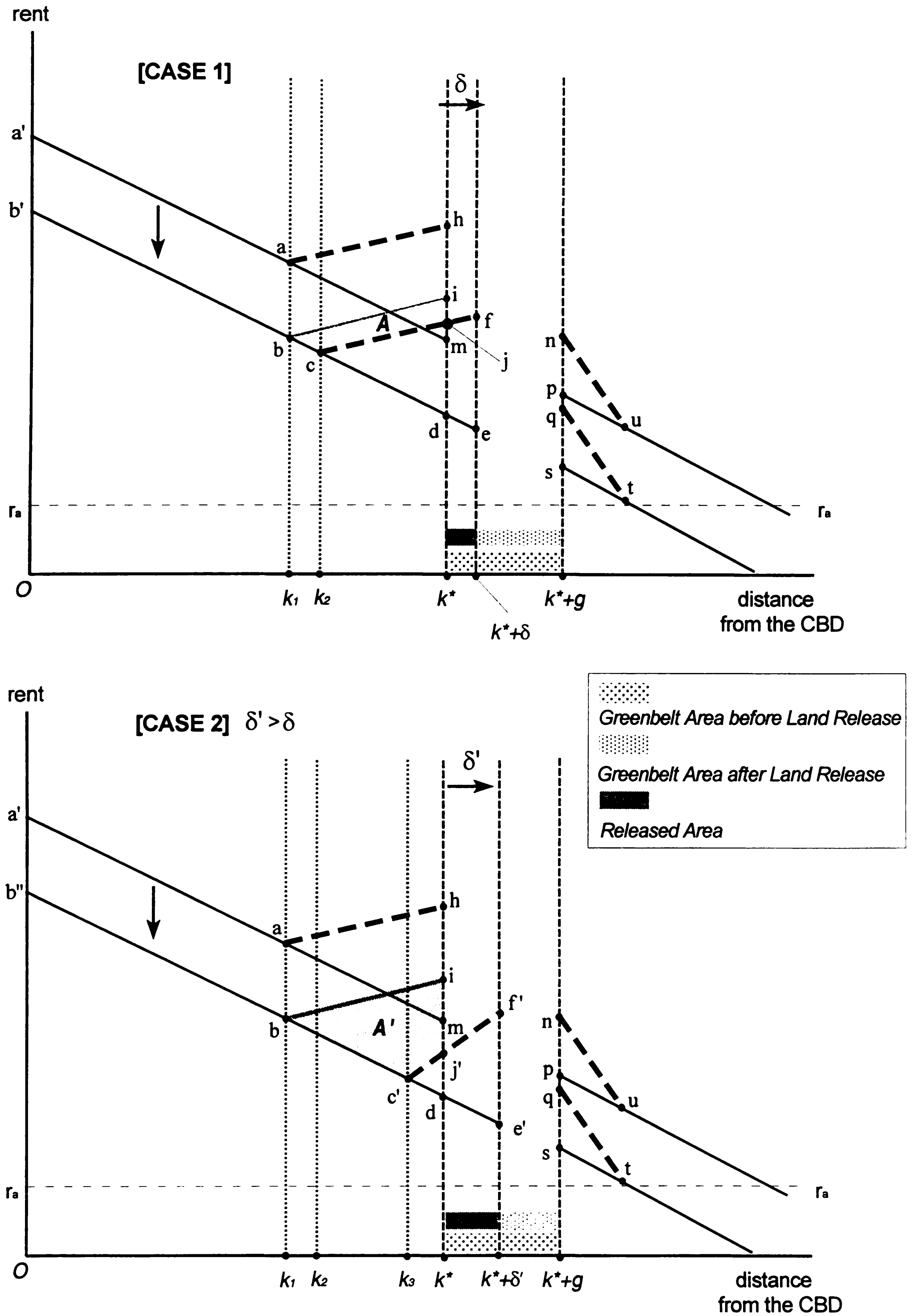
where $EV(k)$ is an equivalent variation at k.

Figure 5. Change of Rent Gradient
- δ km width of land is released from the Greenbelt -

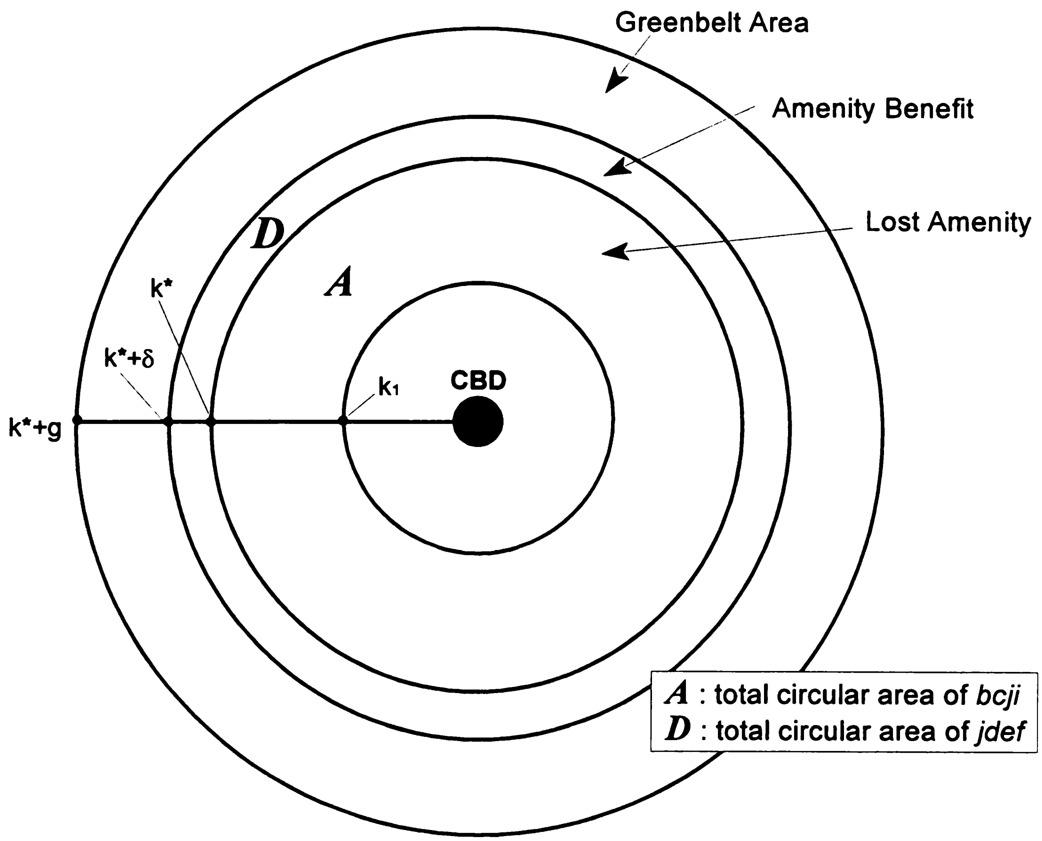
(a) Rent Gradient before and after the Land Release



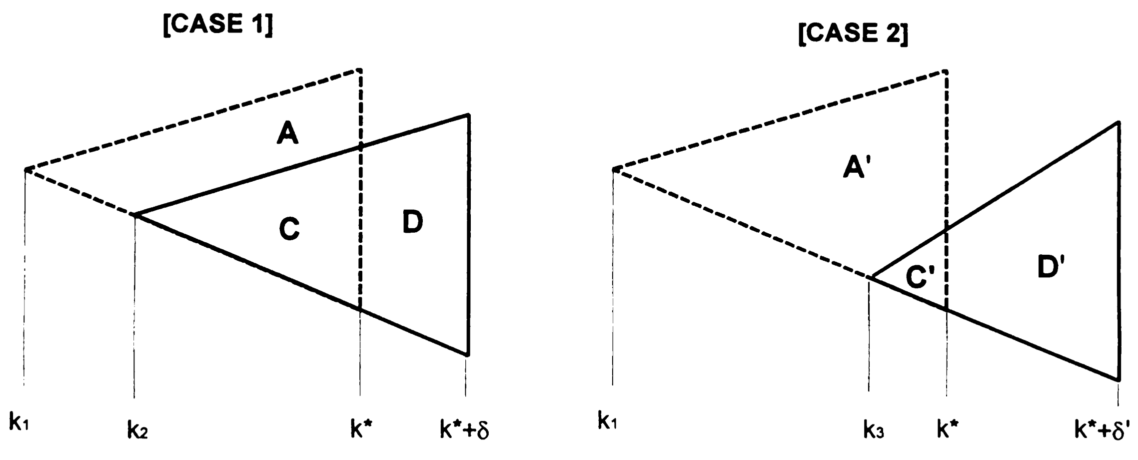
(b) Welfare Changes due to Lost Amenity



(c) Circular Area of Lost Amenity Benefit



(d) Amenity Effect Benefit



Thus the social gain from the land release, considering the amentiy effect, is $W = W_1+W_2$. Utility gain or loss from the amenity changes needs more explanation. Suppose that the amenity effect is good to the location of μ *km* from the Greenbelt inner boundary. If $\mu \geq \delta$, the households at the location of $(k^*-\mu) \leq k \leq (k^*-\mu+\delta)$ may not enjoy the same amount of amenity from the Greenbelt any more because they are located too far away from the Greenbelt. (See <Figure 6-(a)> where we denote the amenity area width as μ). If $\mu< \delta$, the households at the location of $(k^*-\mu) \leq k \leq k^*$ may lose the amenity advantage. These can be either positive or negative depending on how far the amenity effect of the Greenbelt is applied and how wide the land is released. Whether it can be negative or not, it is capitalized into the land rent and housing price through (18) and (19).

Let $e(p,A,u)$ be an expenditure function for a housing price and amenity with a given level of utility, u and $v(p,I,A)$ be the corresponding indirect utility function ($I = y-tk$). By Roy's identity, we can have,

$$(32) \quad -(\partial v/\partial p)/(\partial v/\partial I) = h_D(p,I,A) = B \cdot p^{\varepsilon} I^{\eta} A^{\rho} .$$

Note that the amenity effect is now capitalized into the housing price. The corresponding indirect utility function and the expenditure function are,

$$(33) \quad v^*(p,I) = u^* = -B \cdot (1+\varepsilon)^{-1} p^{1+\varepsilon} A^{\rho} + (1-\eta)^{-1} I^{1-\eta}$$

$$(34) \quad e(p,u^*) = I = [(1-\eta)\{u^* + B \cdot (1+\varepsilon)^{-1} p^{1+\varepsilon} A^{\rho}\}]^{1/(1-\eta)}$$

where $u^* = v^*(p,I)$.

Therefore, if $u^{**} = v^{**}(p_N,I)$ represents the new utility level under the land release, the equivalent variation for a household at k will be given as following,

$$(35)\quad EV(k) = e(p(k),v^{**}) - e(p(k),v^{*}) = e(p(k),v^{**}) - I$$
$$=[(1-\eta)(1+\varepsilon)^{-1}B\cdot A^{\rho}\{p(k)^{1+\varepsilon}-p_N(k)^{1+\varepsilon}\}+I^{1-\eta}]^{1/(1-\eta)} - I$$
$$=[(1-\eta)(1+\varepsilon)^{-1}\{B\cdot A^{\rho}p(k)^{1+\varepsilon}-B\cdot A^{\rho}p_N(k)^{1+\varepsilon}\}+I^{1-\eta}]^{1/(1-\eta)} - I$$
$$=[(1-\eta)(1+\varepsilon)^{-1}\{p(k)\cdot B\cdot A^{\rho}p(k)^{\varepsilon}-p_N(k)\cdot B\cdot A^{\rho}p_N(k)^{\varepsilon}\}+I^{1-\eta}]^{1/(1-\eta)} - I$$
$$=[(1-\eta)(1+\varepsilon)^{-1}I^{-\eta}\{p(k)h_D(p,I)-p_N(k)h_D(p_N,I)\}+I^{1-\eta}]^{1/(1-\eta)} - I.$$

where

$$p_N(k) = D[F'+\{t\beta E\cdot I^{1-\eta}A(k)^{1-\rho}\}/\{(1-\rho)I-t(1-\eta)A(k)\}]^{\{1/(1+\varepsilon)\}}\cdot i^{1-\alpha}$$

(F' is a new intercept, and $I = y-tk$) and $p(k) > p_N(k)$.

Now once we choose $\omega(k)$, we can calculate the social gain/loss. If all the households have identical preference and income, $\omega(k)$ is one for every household and the aggregate EV will be $M\cdot EV$, which is W_2. Also if all the land before the land release is owned by the urban residents, the consumers' gain from the lower housing price is canceled out by their loss from the rental income reduction. Therefore, W_2 is equal to foregone amenity benefit of the residents who live in the amenity area before the land release.

This is illustrated in <Figure 5-(b),(c),(d)>. For convenience of analysis the rent gradient is drawn as linear in <Figure 5-(b)>. After the land release, the rent gradient will shift down everywhere, but the amenity effect area shifts outward because the Greenbelt boundary moves out from k^* to $k^*+\delta$. W_2 is equal to the shaded area of A in the figure. This shaded area is missing in cost/benefit analyses of releasing the Greenbelt in the previous studies. This foregone amenity is generated partly because the Greenbelt is farther by δ *km* than before and partly because the Greenbelt is thinner by δ *km* than before. We can say that the amenity effect is smaller when the Greenbelt is thinner.

Δamh, Δcef, Δnpu and Δqst denote the amenity effect areas near the Greenbelt. If δ *km* wide of the Greenbelt is released from the restriction, then the rent gradient will shift down everywhere, and its intercept moves from a' to b'. Because the Greenbelt

boundary is farther by δ *km* from the CBD after the land release, the amenity area now moves from k_1k^* to $k_2(k^*+\delta)$, and the amenity effect area of Δamh is the same as Δcef after the land release. At locations between k^* and $(k^*+\delta)$ land rent rises from the agricultural rent, r_a to the urban land rent plus the amenity effect, jk^* or $f(k^*+\delta)$. Benefits from releasing land at locations between k^* and $(k^*+\delta)$ will be the area of $dk^*(k^*+\delta)e$ plus the area of *jdef*, and is defined as W_1.

W_2 is equal to the lost amenity of the area *A* because saving from lower rent payment is cancelled out by lost income from lower rent payment in the urban area. Net social gain of releasing land from the Greenbelt would be smaller with the amenity effect than without the amenity effect by *A*. When we look at [case 1] in <Figure 5-(d)>, we know that the total amenity area is same before and after the land release, that is $A = D$. Therefore for society as a whole, *A* is lost but *D* is gained for amenity, and there might be no changes in the total amenity. But looked in at an other way, this might not be ture. Even though Δamh = Δcef, the amenity benefit differes before and after the land release. The circular area of Δamh is smaller than that of Δcef since the farther from the CBD, the larger the diameter is. Δamh = Δcef may lead to conclusion of "area of *bcji* = area of *jdef*", but it is not correct when we look at these from three dimensional view in <Figure 5-(c)>. Even though we have Δamh = Δcef, $A < D$ holds, and the amenity benefit is larger with the land release.

We implicitly assume that the amenity effect does not depend on the thickness of the Greenbelt area. This is illustrated in [case 2] of <Figure 5-(b),(d)>, and $\delta' > \delta$. Therefore, we have a thinner Greenbelt area in [case 2] than in [case 1]. If the amenity benefit area is affected by the width of the Greenbelt, then the amenity benefit declines after the land release because the width of the Greenbelt shrinks by δ′ *km*. Now Δamh is larger than Δc'e'f', and Δnpu is larger than Δqst. The lost amenity benefit, *A*′, will be larger than *A* in the previous [case 1] of Δamh = Δcef, and the net social gain of releasing

land shrinks further if Δamh > Δc'e'f' leads to ***A*** > ***D*** in <Figure 5-(c)>. It illustrates a possibility of shrinkage of the amenity benefit due to interactions of the thickness of the Greenbelt and the three dimensional effect. If the thinner the Greenbelt is, the less the amenity effect is, then the zero amenity location of k_3 is closer enough to the Greenbelt boundary that the total circular volume of Δc'e'f' (***D***) is smaller than the total circular volume of Δamh (***A***). Which effect out weighs the other is an empirical question.

Therefore, we may conclude that the amenity benefit depends on three things: (i) it depends on how large the circumference of the Greenbelt is since more contact gives more amenity, and this is illustrated in <Figure 5-(c)> (ii) it also depends on how far locations are from the Greenbelt and (iii) it depends on how thick a Greenbelt is. The possible importance of thickness is illustrated as a steeper slope of *c'f'* (in comparison with the slope of *cf*) with a closer zero amenity location of k_3 in [case 2] of <Figure 5-(b)> and is shown by the areas of triangles, $(\mathsf{C}+\mathsf{D})$ and $(\mathsf{C}'+\mathsf{D}')$ in <Figure 5-(d)>. When we release the Greenbelt, the resulting amenity benefit depends on the relative strength of three factors. The amenity benefit (D) of Δcef decreases through (i) steeper slope, (ii) zero amenity location closer to the Greenbelt as the Greenbelt is thinner, while the total circular area (***D***) of Δcef increases in a three dimensional view as the Greenbelt is released. Therefore, we have a trade-off between decreasing D and increasing ***D***, and there must be an optimal width of δ^* depending on the relative strength of decreasing D and increasing ***D***.

2. Social Gain from Releasing Land

To calculate the welfare changes from the land release, we need to simplify the land rent function. First, let the land rent be expressed as following,

$$(36) \quad r(k) = exp[b+b_1k+b_2(k^*-k)] = \gamma \cdot exp[b_1k+b_2(k^*-k)].$$

where k is the distance from the CBD, k^* is the distance of the Greenbelt boundary or urban boundary and k^*-k is the distance from the Greenbelt.

Note that we use k and (k^*-k) for the distances from the CBD and Greenbelt respectively while spline estimation of rent gradient includes two more variables for each distance variable. We use only two variables in (36) for making our demonstration simple. When we calculate the welfare gain, the estimated rent gradient will be used. Now the new rent gradient after the land release has to satisfy the following population condition,

$$(37) \quad \int_0^{k^*} n(k)dk = M = \int_0^{k^*+\delta} n_N(k)dk.$$

Since the total population is same before and after the land release, only the intercept of the land rent gradient changes while the slope of the rent gradient remains same if other parameters remain same (see <Figure 5-(a)>.). If we assume that the price elasticity of housing demand is unity, and the net income and effective demand for amenity are same before and after the land release, then the population condition is simplified as follows,

$$(37\text{-}1) \quad \int_0^{k^*} r(k)dk \cong \int_0^{k^*+\delta} r_N(k)dk.$$

The changes in rent gradient are expressed as changes of intercept. Putting equation (36) into (37-1) and rearranging, we can get a rough approximation of intercept ratio as following,

$$(38) \quad \frac{\gamma_N}{\gamma} = \frac{[\{exp(b_1k^*)\}/b_1k^*] - [\{exp(b_2k^*)\}/b_2k^*]}{[\{exp(b_1(k^*+\delta))\}/b_1(k^*+\delta)] - [\{exp(b_2(k^*+\delta))\}/b_2(k^*+\delta)]}$$

and we have estimated values of γ, b_1 and b_2. Note that we transform the distance from the Greenbelt into the distance from the CBD by using $k=k^*-y$. Ratio of γ_N/γ gives the corresponding value of γ_N.

If government releases the 1 *km* wide of land from the Greenbelt, $\delta=1$. The distance from the CBD to the Greenbelt boundary is about 15 *km* on average in Seoul. Coefficients of all variables are reported in <Table 5-(a)>. In our estimation of the rent gradient we use dummy variables in each interval which is set up by knots. <Table 7> reports the results of γ_N in 1975, 1980, 1984 and 1989.

< Table 7 > Rent Gradient Intercepts before and after the Land Release

year	γ	γ_N	γ_N/γ (ratio)	rate of change (%)
1975	3.937	3.707	0.942	-7.84
1980	5.32	5.259	0.989	-1.14
1984	4.479	4.343	0.970	-3.03
1989	5.011	4.8025	0.958	-4.16

Kim (1987) calculated the rent change from the land release and he got 7.7% decrease of the intercept by using 1976 housing survey data. Similar results are found from the KAB data. Change of the gradient intercept ranges from -1.14% to -7.84%. Note that Kim's finding might overestimate the true change in intercept because he did neither consider the amenity effect nor his rent gradient was estimated as a simple linear function.

If the amenity effect exists, the releasing land from the Greenbelt will lead to less social gain than when the amenity effect is ignored because there might be a lost amenity, W_2. We calculate the social gain of the released land from the Greenbelt by using the equation (30). For simplifying the social gain, we integrate the new rent gradient

between 15 and 16 *km*, and the integrated rent is multiplied by the average area of residential land.

$$\int_{15}^{16} r_N(k)\, dk = \begin{array}{l} 1{,}804.49 \text{ won/pyong in 1975} \\ 16{,}662.20 \text{ won/pyong in 1980} \\ 28{,}393.97 \text{ won/pyong in 1984} \\ 80{,}288.36 \text{ won/pyong in 1989.} \end{array}$$

Average residential area between 10 and 18 *km* in Seoul is used as a proxy to calculate the social gain from rent decreases (actual social gain includes the term of ϕ). The average ratio of residential area to the total developed area in Seoul is a little higher than 0.4 in 1988, and we use 0.4 because this ratio in 1975, 1980 and 1984 would be lower than the average residential area ratio of 0.45 in 1988. We assume that the same amount of land in the released area will be developed as residential use. Average residential area is 11.8 million pyong. W_1 is 21.3 billion won in 1975, 196.6 billion won in 1980, 335.05 billion won in 1984 and 947.4 billion won in 1989 respectively.

Now to get the net social gain from the land release we calculate the welfare loss of the lost amenity. The shaded area of A in <Figure 5-(b)> can be divided into a triangle between k_1 and k_2, and a parallelogram between k^* and $k^*+\delta$. We assume that the amenity is zero at k_1. Average distance from the CBD with zero amenity, k_1 is 3.35 *km*, and k_2 is 4.35 *km*. The area of A is 16,981.08 won/pyong (in 1975), 9,094.77 won/pyong (in 1980), 4,980.85 won/pyong (in 1984) and 1,805.70 won/pyong (in 1989) respectively. With the amenity effect of the Greenbelt the net social gain from the land release is less than that without considering the amenity effect. <Table 7-1> reports the social gain of the land release.

< Table 7-1 > Net Social Gains (won/pyong)

year	W_1	W_2	$W (= W_1 - W_2)$
1975	1,804.49	16,981.08	-15,176.59
1980	16,662.20	9,094.77	16,652.25
1984	28,393.97	4,980.85	23,413.12
1989	80,288.36	1,805.70	78,482.66

The results of <Table 7-1> show an interesting finding that W_1, social gain of lower land rent, is found to have increased over the estimated period, while W_2, social cost of lost amenity, decreases. This indicates that the Greenbelt constrains the urban land supply so effectively that the social gain increases during the period of 1975-1989. A growing pressure of population on land prices in the demand side has been stronger than the amenity effect.

3. Social Gain in case of No Amenity Effect

We estimated the rent gradient by using the same spline specification, but we assume that there is no amenity effect this time. Estimated results are reported in <Table 8>. We use the high residential quality only because the high quality is used for calculating the social gains with the amenity effect of the Greenbelt.

Estimated results in <Table 8> are very similar to those in <Table 5-(a)>. Coefficients and their significance give the same numbers and signs as found in the estimation with the amenity effect except for the fit; values of R^2 without the amenity effect is less than those in estimation with the amenity effect. Also the test hypothesis of

spline estimation is rejected at 99% significance level. Overall estimation shows similar results found in the previous estimation with the amenity effect.

< Table 8 > Linear Spline Estimation of Rent Gradient : *No Amenity Effect*

Dependent Variable	Natural Log of High Quality Land Rent			
	1975	1980	1984	1989
constant	4.145*	5.555*	5.26*	5.793*
x	-0.243* (-17.445)	-0.123* (-9.395)	-0.115* (-8.929)	-0.053* (-4.123)
x_5	0.180* (7.397)	0.090* (4.119)	0.137* (6.506)	0.069* (3.349)
x_{10}	-0.153* (-6.372)	-0.110* (-5.338)	-0.111* (-5.591)	-0.054* (-2.903)
adjusted R^2	0.837	0.675	0.402	0.106
N	390	376	354	331

Note ; 1) ( ) is t-value.
2) * is significant at 99%, and ** is significant at 95%.

- Hypothesis Test Results ; F-statistics

Hypothesis	**1975**	**1980**	**1984**	**1989**
$\beta_2 = \beta_3 = 0$	28.446[a]	14.345[a]	22.235[a]	5.947[a]

Note : a denotes that a null hypothesis is rejected at 99%.

< Table 8-1 > Change in Intercepts and Net Social Gains : *No Amenity Effect*

year	γ_N/γ (ratio)	rate of change (%)	W_1 (won/pyong)
1975	0.9913	-0.87	4,026.6
1980	0.9749	-2.51	13,405.8
1984	0.9605	-3.95	59,662.1
1989	0.9538	-4.62	169,265.2

Based on the results in <Table 8>, we can calculate the social gain of releasing land from the Greenbelt in case of no amenity effect. They are reported in <Table 8-1> and show a pattern similar to that in <Table 7-1> ; social gain is increasing during the period of 1975-1989. The second column in <Table 7-1> and the last column in <Table 8-1> show the same net social gain from the land release. The net social gain is larger with assumption of no amenity effect than with the amenity effect because the lost amenity benefit is ignored and excluded from calculations. If we let the proportion of the residential area to the total area be 40% as assumed in the previous calculation of social gain, then the total social gains from releasing the land are estimated to be 47.51 billion won in 1975, 158.188 billion won in 1980, 703.54 billion won in 1980, and 1,997.33 billion won in 1989. These numbers are larger than the results with the amenity effect. Therefore, if there exists an amenity effect of the Greenbelt, and the net social gain is calculated without considering the amenity effect, then the resulting social gain is apt to exaggerate the true social gain.

Chapter V

V. Green Disks for an Alternative to the Greenbelt

The analysis in the land market shows that the amenity of the Greenbelt exists and the net social gain of releasing land from the restriction is smaller than expected or known. In this chapter we propose an alternative system to the Greenbelt.

One of the Greenbelt's goals is to restrict population growth and urban expansion (Hwang, 1976). If one of the Greenbelt's functions is to check urban expansion, then it is related to restricting population growth since the urban area is already checked into a smaller area than without the Greenbelt. Note that construction of new building is restricted inside the Greenbelt. To restrict population growth is not equal to restricting immigration from the rural area, but rather it means that as urbanization goes on, population grows, but there would be a maximum population in the restricted urban area. Additional people must settle outside of the Greenbelt. It brings urban sprawl or leap frog development.

However, the Greenbelt in Seoul seems to fail to achieve this goal -- we cannot calculate the maximum population size of Seoul. Seoul is known to be one of the largest and most crowded cities in the world, crowded over her maximum capacity. The Greenbelt raises urban land price by restricting land supply, on the one hand, and increasing demand through the amenity effect on the other hand. It can be easily seen that the Greenbelt is ineffective in restricting population growth and urban expansion, which lead to urban sprawl, since there exists a suburban area or exurban area beyond the boundary of the Greenbelt in most metropolitan regions, notably Seoul.

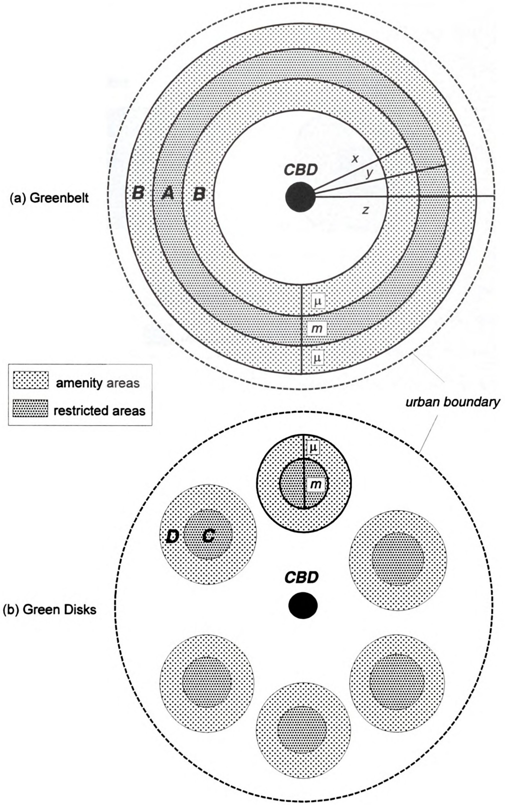
If we accept this proposition, we can conclude that it is not easy to restrict the natural expansion of growing cities by a contrived physical restriction, especially in the long run. Let's put aside the effective growth controls and focus on other sides of the Greenbelt problem -- shortage of urban land supply and the amenity effect of the Greenbelt.

1. Greenbelt and Green Disks

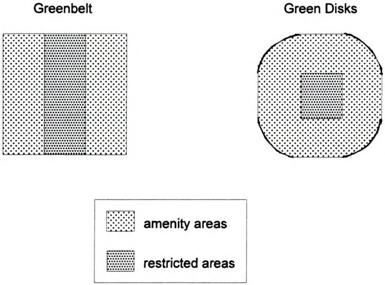
The Greenbelt is generally a ring shape as its name shows but some forms other than a ring shape were proposed in the past, one of which is a wedge shape inserted from city boundary to the CBD. It was proposed in 1968 since the Greenbelt systems in small urban areas in England had failed to work as intended. For the purpose of checking urban expansion, a ring shape of the Greenbelt is better than the wedge shape since the ring shape more effectively restricts the urban area physically. We will look at the ring shape of the Greenbelt since Seoul's Greenbelt is close to a ring shape as shown in <Figure 1-1>, and it fits with our simple analysis of theoretical monocentric city.

<Figure 6-(a)> illustrates a typical example of monocentric city with a Greenbelt. Greenbelt area, A, is m *km* wide and located between x *km* and y *km* from the CBD. City size is determined by z *km* distance from the CBD where rent gradient equals to agricultural rent. Areas next to the Greenbelt, B, are amenity effect areas. We assume that area of μ *km* from the Greenbelt boundary capitalizes the amenity effect so that it has higher rent. In <Figure 6-(b)>, we illustrate an alternative, Green Disks, to the Greenbelt. Green Disks, C, are scattered in the urban area with diameter of m *km* which is the same as the width of the Greenbelt and the areas of the amenity effect, D, have the same width of μ *km* as in the Greenbelt. While the traditional design of the Greenbelt is concentrated in a circular ring, small Green Disks are scattered.

Figure 6. Greenbelt and Green Disks



(c) Comparison of Simple Forms of Greenbelt and Green Disks



We want to examine the differences in the two designs. Which one is more land saving? Which one is more effective in generating amenity effect? How does the transportation cost vary in different designs? Are rent gradients different? If so, how can we explain the difference? At a single glance, there must be physical differences since two designs are different in shape and dispersion. Physical differences will incur changes in economic valuations since individual locational choice changes.

First, we calculate the areas of A, B, C, and D for the Greenbelt and the Green Disks and results are shown in <Table 9-(a)>. Note that μ is set to be one for convenience of calculation and g refers to the number of the Green Disks needed under different settings. If the total area of the Green Disks is equal to that of the Greenbelt (A=C), then corresponding results are shown in the second row. With the same area as with the Greenbelt we can have larger amenity effect area in the Green Disks than in the Greenbelt. This means that the amenity effect is larger and distributed more equally in the Green Disks than in the Greenbelt. The third row shows a possibly more useful application. If we keep the areas of the amenity effect same, we need a smaller area to be restricted for the Green Disks than for the Greenbelt. The Green Disks are land-saving since they restrict less land with the same size of amenity effect as in the Greenbelt. While the Greenbelt decreases the urban land supply, we may increase the land supply when we choose the Green Disks; and the amenity effect areas in both cases are same.

< Table 9 > Greenbelt and Green Disks

(a) Comparisons of Restricted Area and Amenity Area

(i) Greenbelt		**(ii) Green Disks**	
restricted area	**amenity area**	**restricted area**	**amenity area**
m(x+y)π	2(x+y)π	$m^2\pi/4$[1)]	(m+1)π[1)]
if g=4(x+y)/m ; same restricted area		m(x+y)π	4(x+y)(m+1)π/m
if g=2(x+y)/(m+1) ; same amenity area		$(x+y)m^2\pi/2(m+1)$	2(x+y)π

Note : 1) It is each disk area (not total area) because the number of the Green Disks varies with conditions of each city. Others are total areas.

- Calculations of Areas

(i) Greenbelt

restricted area ; $\pi y^2-\pi x^2 = \pi(y^2-x^2) = \pi(y+x)(y-x) = \pi m(y+x)$ since m = y-x.

amenity area ; $\pi(y+1)^2-\pi y^2+\pi x^2-\pi(x-1)^2 = \pi(2y+1+2x-1) = 2\pi(x+y)$.

(ii) Green Disks

restricted area ; $\pi(m/2)^2 = m^2\pi/4$.

amenity area ; $\pi(1+(m/2))^2-\pi(m/2)^2 = \pi(1+m)$.

# of Green Disks for same restricted area ; $g = 4\pi m(y+x)/m^2\pi = 4(y+x)/m$.

# of Green Disks for same amenity area ; $g = 2\pi(x+y)/(m+1)\pi = 2(x+y)/(m+1)$.

(b) Numerical examples for comparing the total restricted areas and amenity areas

Numerical examples of (x,y,m)	(10,20,10)		(15,20,5)	
Area	**restricted**	**amenity**	**restricted**	**amenity**
Greenbelt	300π	60π	175π	70π
Green Disks (i) same restricted area	300π	132π	175π	168π
(ii) same amenity area	150π	66π[1)]	75π	72π[1)]

Note : 1) We use g = 6, 12 instead of 60/11, 70/6 respectively in order for the results to be expressed as a simple integer. 2) We set μ=1 for simplifying the calculation.

Numerical examples illustrate the above implications more clearly. We have two cases of (x,y,m) = (10,20,10), (15,20,5). For the number of Green Disks, g, we use the closest integer solution for the same amenity area (the last row in <Table 9-(b)>). However, the critical implication is unchanged. In <Table 9-(b)>, we have two different cases; the cases of the same restricted area and the same amenity areas. These results are not surprising because in the Green Disks the amenity effect areas per restricted area are larger than those in the Greenbelt. All areas around the Green Disks are amenity effect areas while only two sides of areas are amenity areas in the Greenbelt as shown in <Figure 6-(c)>.

For the same restricted area, both examples of (x.y.m) show more widespread amenity effect under the Green Disks and the amenity effect areas increase more than twice; by 120% and 140% respectively each case. For the same amenity effect areas, both show a huge land-saving under the Green Disks. In the first example we need only half of the land while we need less than half in the second. This indicates that the rent gradient could shift downward at every location and the urban land price would fall under the Green Disks systems.

From the above examples, we show that under the Green Disks, we may restrict less land physically with the same amenity effect areas. Land-saving and bigger amenity effect areas are not enough to conclude that Green Disks are superior to a Greenbelt. We have to look at utility changes in both individual and social levels. In urban economics, transportation cost is critical to determine residential location and the marginal increase of transportation cost must be equal the marginal saving of rent payment at equilibrium. With the changes of the amenity effect and the transportation costs, the rent gradient might be higher than with the Greenbelt and urban residents might lose some utility under the Green Disks.

The simple version of equilibrium condition of locational choice (equation 4-1) may be expressed in an indirect utility functional form. We get the following after totally differentiating the indirect utility function, $V=V(r,t,A)$,

$$(39) \quad dV = V_r dr - V_t dt + V_A dA.$$

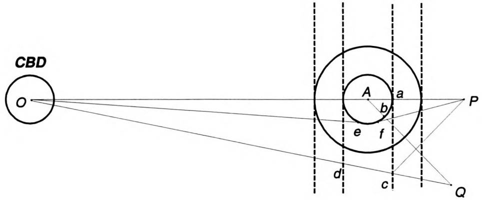
Note that the above indirect utility function is different from that in equation (39). In the short run, population size is fixed. So when there are changes in variables, dV is not equal to zero since population size no longer changes to restore the utility equalization condition at equilibrium. Then utility level is endogenous as in a closed city model. Replacing the Greenbelt by the Green Disks will decrease rent everywhere and changes the transportation cost and amenity effect without causing relocation.

2. Changes of Welfare and Rent Gradients under the Green Disks

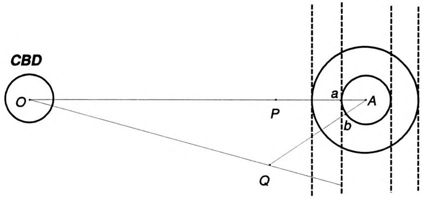
<Figure 7> is useful to explain these utility changes. In all three panels, the central point of urban area, O, is located in the CBD and that of the Green Disks is A. For simplicity, let the Green Disks be located in the Greenbelt area and two locations at P and Q have the same distance from the CBD. Panel (a) shows the case where both P and Q lie outside of the outer boundary of the Greenbelt while in panel (b), they lie inside the inner boundary. In panel (c), both lie between the inner and outer boundary of the Greenbelt.

Figure 7. Amenity Effect of Green Disks
- along the distance from the CBD -

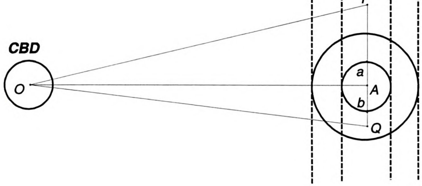
(a)



(b)



(c)



In panel (a), P and Q lie outside the Greenbelt outer boundary. If dc is the nearest door to get into the CBD through the Greenbelt, total commuting distance is PcO at P and QO at Q under the Greenbelt. Under the Green Disks, PfeO is the shortest commuting distance for P that is much shorter than PcO while there is no change in commuting distance at Q. The distance from the outer or inner boundary of the Greenbelt indicates how much a location has an amenity effect, that is, the closer to the boundary it is, the larger the effect is. While P has same amount of amenity in both systems, Q will experience a longer distance and less amenity effect. All locations between P and Q have less amenity effect and more saving in commuting cost since they are located farther to the boundary. If it is close to Q, the amenity loss is greater than the transportation cost saving. If close to P, the amenity loss is smaller than the transportation cost saving. Both P and Q will benefit under the Green Disks if the amenity effect loss is smaller than the sum of rent and the transportation cost saving effect on utility. For locations inside the inner boundary, the amenity effect loss is dominant while there is neither gain nor loss in commuting distance as shown in panel (b). Again, if the rent saving effect is stronger, then the amenity effect loss could be fully compensated so that the utility may rise. In panel (c), P and Q, between the inner and outer boundary of the Greenbelt, benefit from transportation cost saving but they have to pay higher rents after their locations are released from the Greenbelt. In the aggregate, they might lose if the amenity effect loss is greater.

On a social level we cannot say which system gives more utility without constructing the social welfare function. Furthermore, the assumption that the amenity effect loss is smaller than the sum of the rent and transportation saving effect needs more verification. Its validity depends on the form of the utility function one chooses and the relative weights on three different effects. In the long run, the urban area expands with growing population size, but these are fixed in the short run. Suppose that the Greenbelt

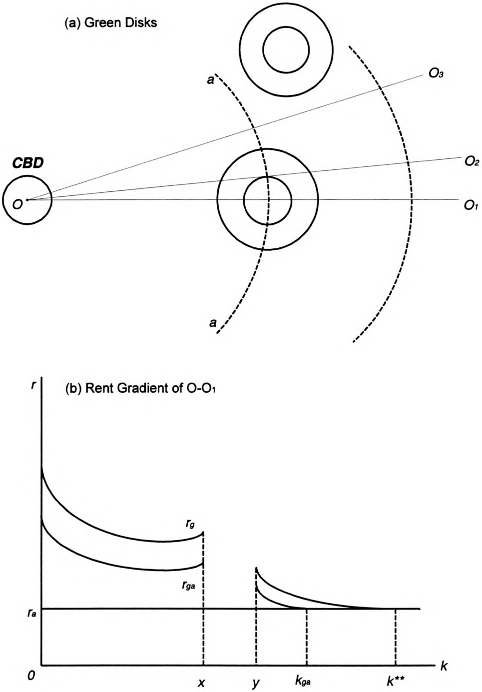
is established for containing future urban expansion. The Greenbelt might not be binding when first established. When the urban area is growing outward in the long run, the Greenbelt shall be binding at last. Weight on the amenity effect would be lower and might be negligible at the beginning stage of urban growth since there might be not only less congestion and environmental problems, but the urban area is rather small. However, in the long run, shortage of land might be the more serious problem than the amenity loss since it affects more urban residents in the low and middle income classes--in the panel (a) and (b), notably as in Seoul. If each individual has the same preference, the total amenity loss is smaller than the total gain of rent saving and transportation cost saving since the rent saving is applied to all residents and more residents may give less weight on the amenity loss.

In the aggregate we cannot conclude whether it is loss or gain without defining the social welfare function. As in the basic model for the housing market, we can assume that each member has equal weight in the social welfare function. Under equal weight of each member, we can say that the social welfare will increase under the Green Disks. For members in the panel (a) and (b), there is welfare gain while a loss exists for members in the panel (c). Note that this conclusion is valid only when there is no movement among members after displacing the Greenbelt by the Green Disks.

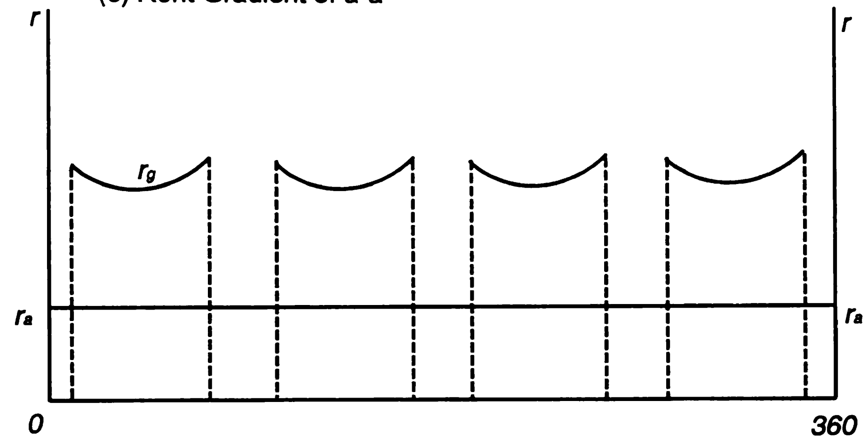
As shown above, the Green Disks are land saving and supply more land for urban uses. This increase in the land supply shifts the rent gradient downward at every location except for the area released from the Greenbelt restriction. <Figure 8> shows the induced shifts of the rent gradient. We can have several different rent gradients under the Green Disks as shown in panel (a) since the restricted area is not a ring shaped.

In the panel (b), more land available for urban uses will shift down the rent gradient in the range of O-O_1 except for the restricted area of (x-y) where one receives agricultural rent. This shift in the rent gradient from r_g to r_{ga} will shrink the urban area

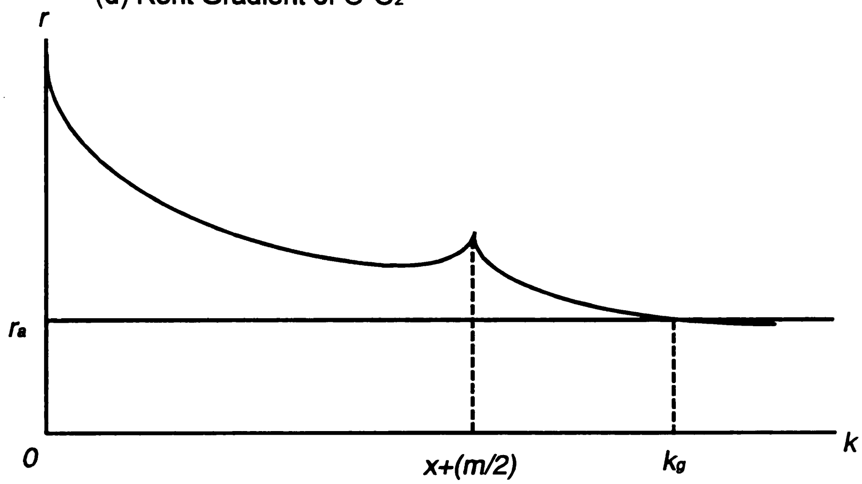
Figure 8. Rent Gradients in case of the Green Disks



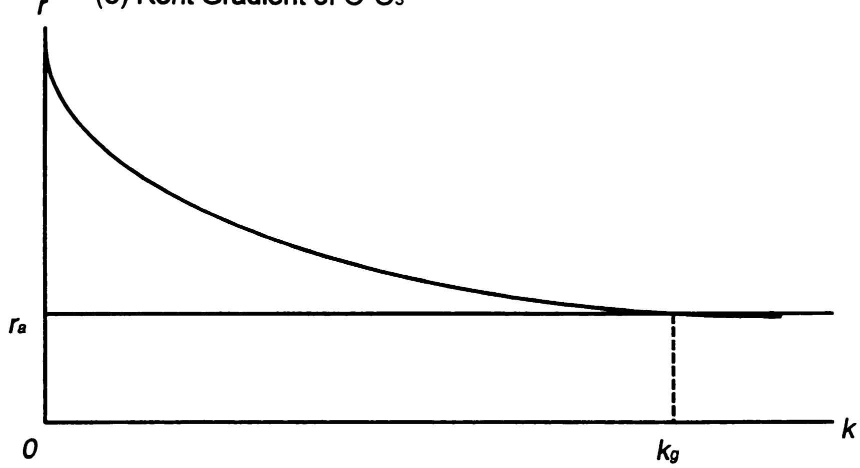
(c) Rent Gradient of a-a



(d) Rent Gradient of O-O2



(e) Rent Gradient of O-O3



from k^{**} to k_{ga}. Urban sprawl is less severe in the Green Disks system than in the Greenbelt system. The Green Disks are neither a belt nor concentrated. So rent varies even in the same radial circle as shown in the panel (c). As in the panel (b), the closer to the Green Disks a location is, the higher a rent is due to larger amenity effect. When we rotate O-O_1 closer to O-O_3, x and y will move toward each other and the rent gradient will move along r_{ga} in the panel (c). Rotating more to O-O_2, x meets y at x+(m/2) where rent gradient shows a hump as in the panel (d). At last, we have a smoothly downward sloping rent gradient but its slope is flatter for O-O_3 as in the panel (e).

3. Urban Disks : Seoul and Satellite Cities

The Green Disks are preferable to the Greenbelt because they guarantee more equitable distribution of the amenity effect and more land supply. As seen in <Figure 1-1>, the actual Greenbelt in the capital region resembles the Urban Disks in <Figure 9-(a)>. The Greenbelt starts around the urban boundary of Seoul and the satellite cities are surrounded by the Greenbelt. This simplified form of the Greenbelt approaches to the Urban Disks somewhat.

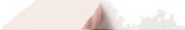
Let the distance from the CBD to the Greenbelt be x and s respectively for Seoul and the satellite cities, and the distance from the CBD to the outer boundary of the Greenbelt be y, and m denote the thickness of the Greenbelt, μ denote the amenity area. Total restricted area under the Greenbelt is $\pi m(x+y)-\pi ns^2$ if the number of the satellite cities is n and the corresponding amenity area is $\pi\mu\{(2s-\mu)n+(2x-\mu)\}$. The amenity area concentrates around the boundaries of Seoul and the satellite cities.

In the long run the urban areas expand outward. Growing satellite cities expand more than Seoul; because Seoul is already crowded, the satellite cities are more attractive

to live in with transport development. A small part of the Greenbelt around the urban areas has to be released in the long run in order to meet the increasing demand for urban land because of demand pressure. This shrinks the total Greenbelt area and may affect the amenity effect due to less green areas. The Greenbelt may be demolished totally after the satellite cities expand further. One of the Greenbelt's merit is its amenity effect and the urban residents near the Greenbelt enjoy it. If the Greenbelt shrinks too much to have zero amenity effect or close to zero amenity effect, then there will be a social loss since the residents cannot enjoy the amenity benefit any more.

It is illustrated in <Figure 9-(b)>. The diagram implicitly assumes that the area beyond y *km* from the CBD of Seoul will not generate amenity effect. But different assumptions are possible. If the urban areas expand, Seoul and the satellite cities are not separated by the Greenbelt any more because some part of the Greenbelt is released to urban uses. If we assume that the urban areas expand by μ, then the resulting amenity area in Seoul disappear while that in the satellite cities shrinks. From <Figure 9-(b)> the amenity area in the satellite cities may increase if the Greenbelt is thick enough to surround all the satellite cities. But the Greenbelt area decreases due to the urban expansion and its erosion. The amenity area decreases roughly by two thirds of that before expansion. Total restricted area decreases to $\pi\{(y+x)m-2\mu(y-m')-n(s+\mu)^2\}$ where $m'=(y-x-\mu)$. Roughly the amenity area shrinks to $(2/3)[\pi\mu\{(2x+\mu)+n(2s+\mu)\}]$. The amenity area concentrates around some areas of the boundaries of the urban areas. The amenity benefit decreases to incur a social loss due to shrinkage of the amenity area.

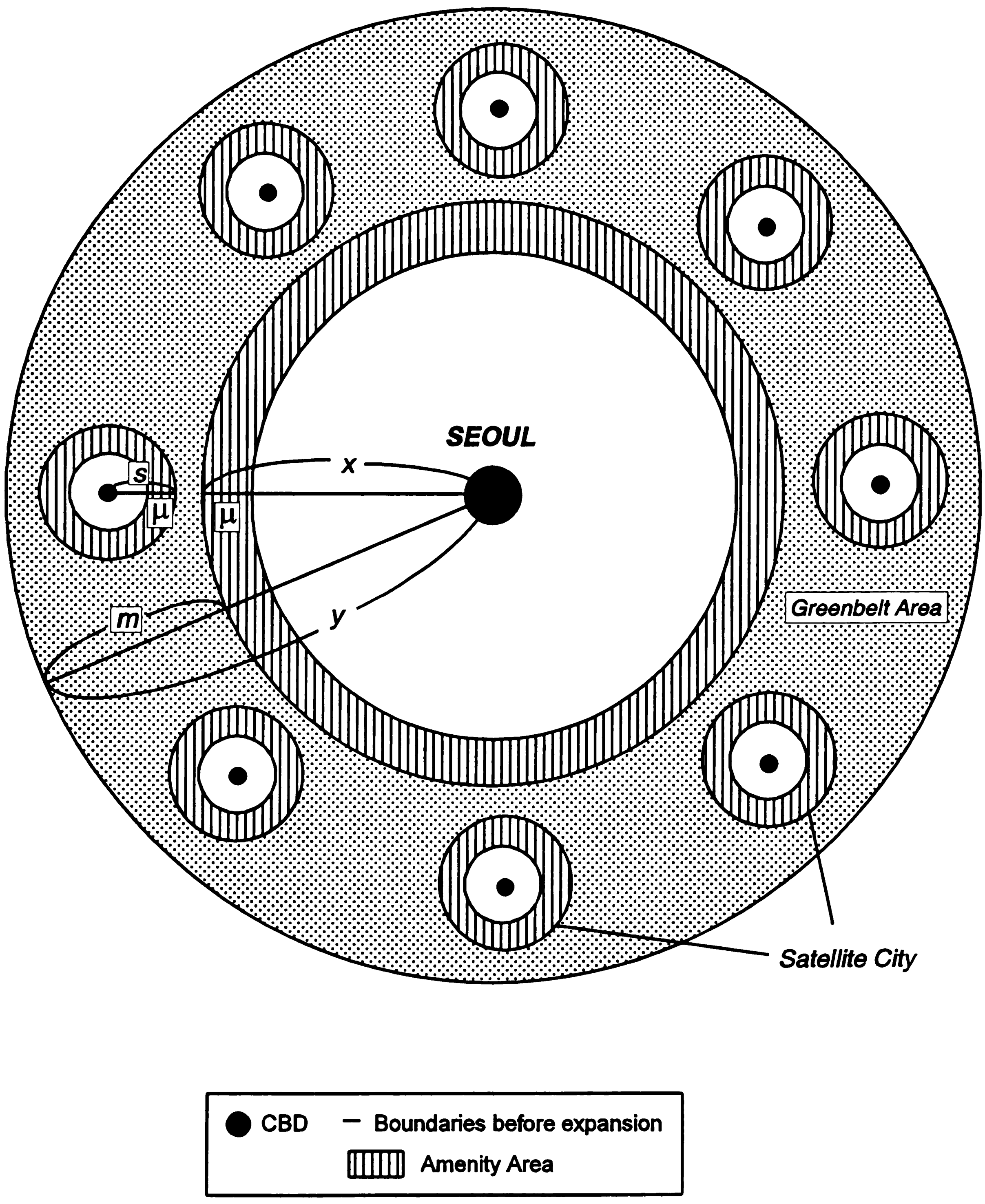
However, with the Green Disks we may avoid such a social loss. If properly designed and enforced, the Green Disks can remain effective in generating the amenity even in the long run. As shown in one stylized possibility of <Figure 9-(c)>, the Green Disks remain untouched after the urban areas expand. More residents may enjoy the amenity as the urban boundaries are close to the Green Disks. Total restricted area under



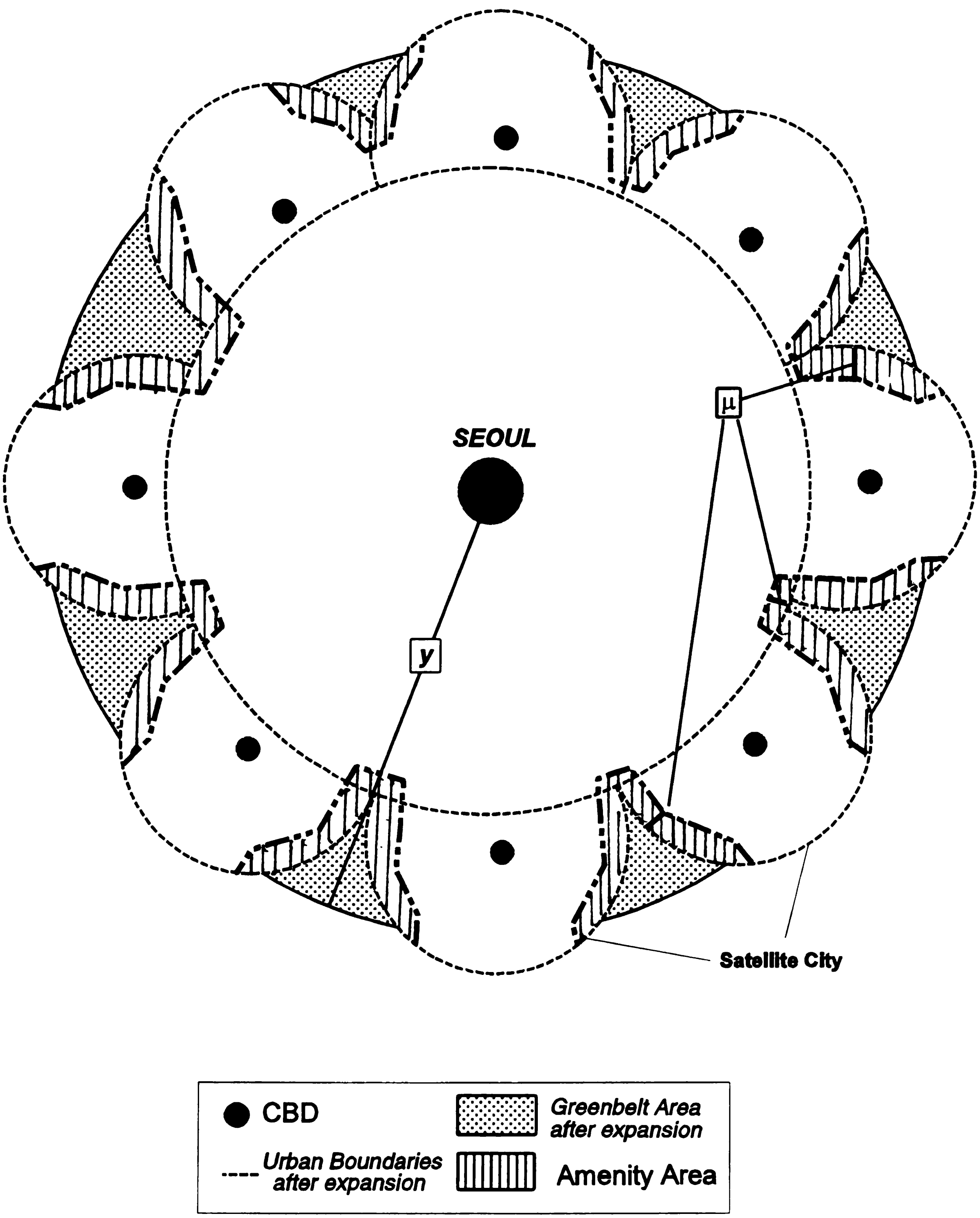
the Green Disks is $\pi g(m/2)^2$ and the amenity area after expansion is $\pi\mu g(m+\mu)$ where g denotes the number of the Green Disks. The merits of the Green Disks are already noted; (i) they can provide more urban land than the Greenbelt can. (ii) amenity benefits are more equally distributed. We add one more merit to these; it is consistent with the urban expansions of the satellite cities in the long run.

Figure 9. Seoul and Satellite Cities

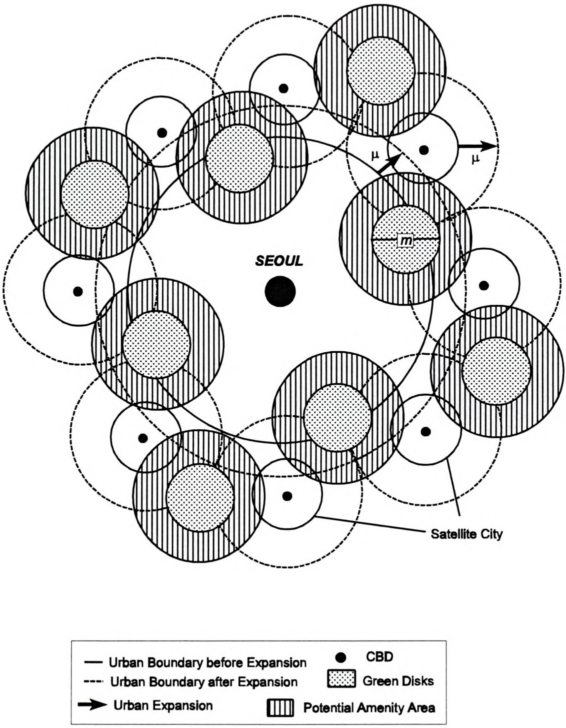
(a) Before Expansion of Cities



(b) After Expansion of Cities



(c) Urban Expansion and the Green Disks



Chapter VI

VI. Conclusions

In Korea a deregulation movement has begun to flourish. One of the criticized policy measures is the Greenbelt restriction because it limits the urban land supply in Seoul and other major cities. The model used to provide the analytical basis of criticism does not count on the amenity effect of the Greenbelt. In this paper we analyze the amenity effect of the Greenbelt and reconsider the validity of the deregulation movement for the Greenbelt.

The simple models of land and housing markets are amended to include the amenity attributes. Our models developed here are designed not only to have as much analytical power as the simple monocentric model but to explain the heterogeneity of housing services in the real world. If an amenity from the Greenbelt varies with the distance to the Greenbelt, housing on different parcels will provide different degrees of amenity. If the Greenbelt is a circular ring around the urban areas, the monocentric model should keep its full analytical power in explaining the amenity effect. The amenity effect is capitalized into the land rent and value, and the house value and rent vary as the amenity variable enters the utility function or housing demand function.

Based on the theoretical findings, empirical analyses were carried out for the land market. Empirical results show that an amenity effect exists in the land market. In the land market analysis, we estimate the rent gradient by using a linear spline functional form. Even though the overall fit decreases during the estimated period, most coefficients are significant. Considering the trend of the coefficients, the rent gradients have been flatter during the estimated period. Oddly enough the highest rents are not at

the immediate boundary of the Greenbelt but 1 or 2 *km* inward. This distance rose until 1980, then stabilized. Some tentative reasons for this pattern were explored in chapter III, but further study would clearly be helpful.

For population gradients we found that population is shown to decrease with the distance from the Greenbelt while it increases with the distance from the CBD. Estimated coefficients suggest that such relationships are stronger over the estimated period. It means that population is relatively concentrated near the Greenbelt. However, we cannot conclude that the amenity of the Greenbelt has a pulling effect on the population because (i) it may be coincidential that the high population density areas are close to the Greenbelt. (ii) increasing income, car ownerships and the public transport system allow people to live in locations far from the CBD without incurring high cost.

If the amenity effect exists, then releasing land from the Greenbelt restriction might decrease the social gain due to loss of the amenity benefit. It may be that the changing the width of the Greenbelt, not just its distance from residences, has important implications abut the amenity effect. We found the trade-off between decreasing amenity benefit from the thinner Greenbelt and increasing amenity area from more contact in circular areas. With the special assumptions outlined in chapter IV, we calculated the social gain of the land release. Our calculation is -15,176 won/pyong(1975), 16,652 won/pyong(1980), 23,413 won/pyong(1984), and 78,482 won/pyong(1989) respectively as the 1 *km* wide of land is released from the Greenbelt. Net social gain from releasing the land are 4,026 won/pyong in 1975, 13,405 won/pyong in 1980, 59,662 won/pyong in 1984, and 109,265 won/pyong in 1989. In this sense the Kim's finding overevaluate the net social gain. Our data is known to represent only 70% of the real market value of land. After adjusting this underestimation, we have -21,680 won/pyong, 23,789 won/pyong, 33,447 won/pyong, and 112,117 won/pyong in the same years.

If 40% of the total area is developed as residential use, then we can get 11.8 million pyong of newly developed residential area and 47.6 million pyong of the amenity benefit area. Taking these numbers into account, we can have the results of net social gains reported in <Table 10>. Generally the net social gain of releasing land from the Greenbelt restriction is overevaluated if the amenity effect is not considered properly. The degree of overevaluation has increased over the estimated period of 1975-1989. Comparing them with the GNP (current prices) of the corresponding years, the ratios of W in the fourth column in <Table 10> are -7.76% in 1975, -0.64% in 1980, 0.14% in 1984, and 0.61% in 1989 respectively, while those of W_1 in the fifth column in <Table 10> are 0.47% in 1975, 0.43% in 1980, 1.0% in 1984, and 1.42% in 1989.

< Table 10 > Social Gains of Releasing Land, and Amenity Effect (billion won/month)

year	(a) With Amenity Effect			(b) Without Amenity Effect	Overevaluation ; (b) - (a)
	W_1	W_2	$W (=W_1-W_2)$	W_1	
1975	21.3	808.3	**∇787***	**47.5**	834.5
1980	196.6	432.9	**∇236.3***	**158.2**	394.5
1984	335.05	237.1	**97.95**	**703.5**	605.55
1989	947.4	86.0	**861.4**	**1,997.3**	1,115.9

Note : ∇ represents negative numbers, and they indicate the social loss.

Our analysis is not problem free. First, our simple model is far from perfect because it does not consider the secondary urban centers and commuting time. This lack might be critical in urban analysis because modern urban life is very sophisticated. Second, our calculation of net social gain might be different from the true social gain because we assume unitary price elasticity of housing demand. Also it is assumed that the net income and amenity demand remain unchanged before and after the land release.

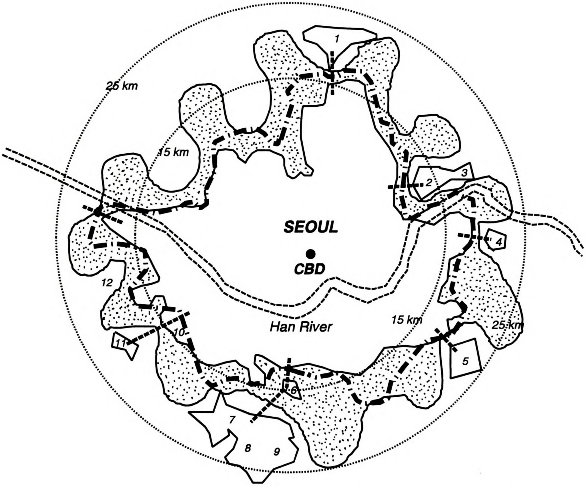
To sum up, if the Greenbelt has a pervasive effect on the urban land supply, eliminating the Greenbelt restriction is an alternative. However, the Greenbelt is found to be effective in generating an amenity effect. Nowadays the environmental problem is one of the major issues in the world and is also critical enough to have the attention of scholars. With respect to long run perspectives of the environment as well as simple benefit cost analysis, we have to reconsider the deregulation of the Greenbelt.

We propose the Green Disks or scattered reserves, which will help with both the land supply shortage and the amenity in Seoul. With the Green Disks, we need less land for the same amenity effect. Above all, we can utilize the land released from the Greenbelt for other urban uses. It will increase the urban land supply, which will lower the rent gradient at every location. Total urban utility may rise with a more equally distributed amenity effect.

<Figure 10> shows that the Greenbelt is displaced by the scattered reserve areas as an alternative. The scattered reserve areas are drawn according to various principles, as follows: First, they must resemble the Green Disks in form. Second, they should approximate the Greenbelt to minimize the changes. Third, they circumscribe other satellite cities to maximize the amenity effect areas. Compared with the Greenbelt in <Figure 1-1>, the scattered reserve areas are smaller than the Greenbelt areas. Note that we do not consider the political and administrative feasibility of the Green Disks or scattered reserve areas. In order to implement the idea of Green Disks, the political and administrative feasibility have to be considered.

The simple model with amenity attributes seems to be valid to analyze the Greenbelt. Existence of the amenity effect of the Greenbelt leads to the conclusion that the social gain from land release might not be as large as perceived. It seems desirable to adjust the form of the Greenbelt rather than just to discard the whole idea. The Green Disks or scattered reserve areas may be proper for replacing the Greenbelt.

Figure 10. Examplary Scattered Reserve Areas in Seoul as an Alternative to the Greenbelt



Satellite Cities

1	Eujeongbu	7	Anyang
2	Guri	8	Gunpo
3	Migum	9	Euwang
4	Hannam	10	Kwangmyung
5	Sungnam	11	Siheung
6	Kwachon	12	Buchon

Boundary of Seoul

Green Disks or Reserve Areas

Major Transportation Route

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