JOURNAL OF URBAN ECONOMICS **43,** 362–384 (1998)
ARTICLE NO. UE972051

Analysis of Urban Land Shortages: The Case of Korean Cities*

Jae-Young Son

Department of Real Estate Studies, Kon-kuk University, 93-1 Mo-jin Dong, Kwang-jin Gu, Seoul, 143-701, Korea

and

Kyung-Hwan Kim

Department of Economics, Sogang University, CPO Box 1142, Seoul, Korea

Received April 30, 1996; revised March 20, 1997

I. INTRODUCTION

Both natural constraints and government regulations on urban land use can cause urban land shortages, and hence higher prices of urban land and housing than otherwise. There have been attempts to investigate the differential effects of natural and contrived restrictions on land price. For example, Rose [10] found that natural constraints have a significant positive impact on land value while monopoly zoning power makes a smaller contribution in explaining inter-city variations in urban land price. On the other hand, Pollakowski and Wachter [8] analyzed the impact of land use controls measured by an index of restrictiveness of zoning and confirmed that land use regulations raise the prices of housing and developed land. To the best knowledge of the authors, however, none of the published empirical studies including the two cited above actually measure the amount of shortage of urban land at the city level. Instead, land supply variables are employed together with demand variables such as income and population size to determine their impact on land or housing prices.

This study seeks to fill the gap in the literature first by developing a measure of the urban land shortage/surplus from an analysis of land price

*Comments by Jan Brueckner and two anonymous referees on an earlier draft are gratefully acknowledged.

0094-1190/98 $25.00

gradients within the framework of the standard monocentric urban model. This is done in Section II. Then the model is applied to measure the magnitude of urban land shortages in Korean cities. Korea has a system of stringent controls on the conversion of land use from rural to urban as well as exhibiting a remarkable pace of economic growth and urbanization. A major consequence of the artificial scarcity of developable land caused by government regulation and rapidly increasing demand for urban land is that housing is unaffordable to a large part of the country's urban population [2, 4]. In order to test whether urban land use controls are mainly responsible for urban land shortages, extensive data on land value on 300,000 plots in 171 cities and counties in Korea were used to compute the amount of land shortages (Section III) and to relate the estimated shortage figures to natural and regulatory constraints (Section IV). Section V concludes the paper with a summary of major findings and policy implications.

II. CONCEPTUAL FRAMEWORK FOR MEASURING URBAN LAND SHORTAGE OR SURPLUS

1. *Allocation of Land between Urban and Rural Use in a Monocentric City Model*

Our approach to measure shortage/surplus of urban land in a given city[1] builds on the standard monocentric city model with a predetermined urban center (CBD) on a featureless plane with no topographical and regulatory constraints.[2] The standard model recognizes two competing types of land use: urban land used for housing, industrial, commercial, and infrastructure; and rural land devoted to agricultural, forestal, and pastoral uses. The opportunity cost of urban land, i.e., the rural land price, is assumed to be zero or a fixed constant in simple versions of the model. However, the price of rural land may vary with distance from the center because proximity to the center benefits certain kinds of non-urban economic activities. In addition, the cost associated with converting rural land into urban use and installing urban infrastructure must be added to the opportunity cost of urban land.

[1] In this paper, the term "city" refers to an area with an urban center surrounded by rural hinterland. When it is used in contrast to the "county," however, the city is a statutory entity with a legal jurisdiction. It should be noted that, in Korea, the city and the county are separate administrative units with mutually exclusive jurisdictions. An urbanized area within a county can gain the status of a city when its population reaches 50,000. The city and the county belong to the province, but the six largest cities have the same legal status as a province.

[2] Refer to [1] for an excellent exposition of the model.

Our model is illustrated by the first diagram of Figure 1, where BB represents the bid price curve (or, from the empirical point of view, the land price gradient) for urban land and RR is the price of rural land inclusive of infrastructure cost. Each curve slopes downward and has a positive intercept. Curve BB is steeper than RR because accessibility as measured by the marginal transportation cost is more important for urban economic activities than for rural ones. BB also has a higher intercept, implying that urban land commands a higher value than rural land at the center even when the cost of conversion is taken into consideration.

The allocation of land between urban and non-urban use is governed by relative bid rents or bid prices of competing potential users. Each plot of land is occupied by the highest bidder. Point A in the diagram represents the unfettered equilibrium at which the owner of a plot of land is indifferent whether it is rented for urban or rural use. Land located within A miles from the center will be used for urban purposes, whereas those located farther out will be devoted to rural activities. Once price gradients are estimated for urban and rural land, equilibrium point A can be found and the equilibrium amount of urban land can be calculated as the area of a circle with radius A. The equilibrium allocation of land between urban and non-urban use is socially efficient because the rent on urban land at the urban boundary reflects its social opportunity cost. A corollary is that any deviation from the market equilibrium entails efficiency loss.

In a particular city, natural or contrived constraints on land supply may cause the actual allocation of land use to deviate from the equilibrium and hence the optimum level. In order to measure the size of such deviation, we define urban land shortage or surplus (S) in a city as the difference between the (unobserved) equilibrium quantity of urban land (U^*) and the actual amount of land currently being used for urban purposes (U),

$$S = U - U^*. \tag{1}$$

A positive value for S represents a surplus of urban land and a negative value indicates a shortage.

Alternatively, we normalize the amount of shortage/surplus of urban land to obtain a measure as a percentage of the area currently used for urban purposes,[3]

$$s = \frac{U - U^*}{U} = \frac{S}{U}. \tag{2}$$

[3] The reason we prefer U to U^* as the denominator in the definition is twofold. First, U^* can take a value of zero as is explained below. Second, it enables us to interpret the computed figure in a more straightforward manner. For example, we can conclude that the amount of urban land shortage in a certain city is equivalent to 200% of the amount of land currently being used for urban purposes.

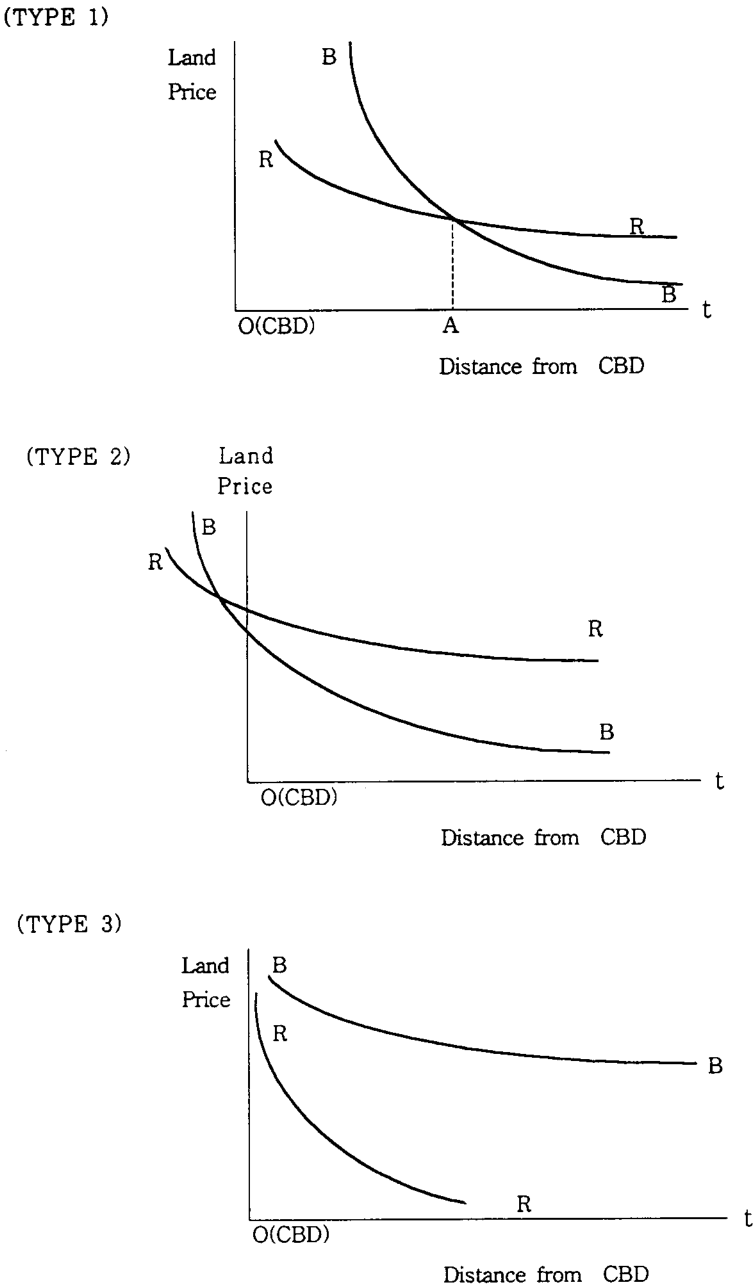

FIG. 1. Three types of equilibrium land allocation between urban and rural use.

Although published data on U are available at the city level, U^* must be computed using land price data. Calculation of U^* is conceptually straightforward in a standard monocentric model with no land use restrictions, but critical assumptions of the model may not be satisfied in real world cities. Therefore, we devise a method to deal with the natural and contrived constraints which cause real cities to exhibit a spatial structure different from that derived in the standard model. Since our approach cannot accommodate all violations of the standard assumptions, we will identify conditions under which our method is likely or not likely to produce reliable estimates of land shortages.

2. *Discussion of the Assumptions*

Topography

The standard monocentric model assumes that the city is situated in a featureless plane with no topographical constraints. In a real world city, there may be bodies of water or mountains. To the extent these topographical constraints are effectively overcome by bridges, tunnels, and other transportation facilities, easy accessibility to the CBD justifies the assumption of a featureless plain. However, there must be cities where topography hinders access to the CBD and the estimated land price gradients are distorted.[4] A region consisting of several islands, each having its own population center is one example, and an urban area developed linearly along a transportation corridor is another. In such cities, the slope of the urban land price gradient will be very small, resulting in an overestimation of the optimal urban land area. Although our data do not allow us to determine *a priori* whether topographical constraints cause distorted results, a topographical problem is suspected if the slope of land price gradients is unusually small.

Another potential problem arising from irregular topography is that the estimated land price function could be misinterpreted in calculating the shortage of urban land. Take the case of a city developed around a waterfront CBD. If one assumes that the city is circular in shape, the equilibrium quantity of urban land U^* would be calculated as πA^2, but the correct figure is one-half of the estimate. This problem can arise whenever the overall shape of the city is much different from a circle or the CBD is located in a far corner of the city. To deal with such situations, we define a topographical adjustment factor and apply it when computing the equilibrium quantity of urban land.

[4] Rose [10] defines the concept of a finite land supply as a weighted sum of units of land space available in a city, taking topographical constraints into consideration.

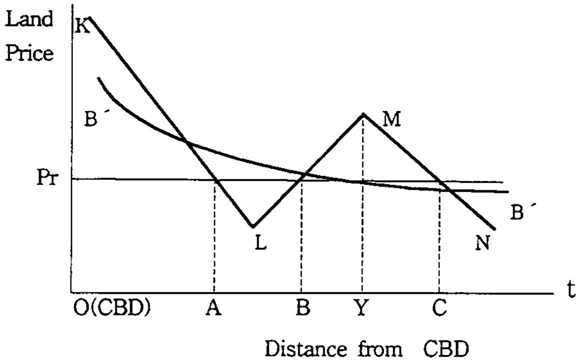

FIG. 2. Equilibrium land use in a city with subcenters.

Monocentricity

The assumption that all economic activities take place at a single predetermined center is highly restrictive.[5] Some cities may have well-developed subcenters which entail more than one peak of urban land price gradient. Figure 2 illustrates a city with a set of subcenters located along a band at Y miles from the center. Curve $KLMN$ is the true profile of urban land price, whereas Pr represents a fixed price of non-urban land. In equilibrium, plots between O and A and those between point B and point C will be used for urban purposes, while plots located between A and B and those beyond point C will be used for non-urban activities. If one fits a monotonically declining urban land price schedule ignoring the existence of subcenters, a line like $B'B'$ will be estimated, and the equilibrium quantity of urban land will be calculated incorrectly.[6]

This problem can be avoided if one has accurate information on the location of subcenters as well as the CBD. Since our data set does not have such information, there is room for inaccuracy in our estimate of urban land shortage for some cities. This problem can be detected by closely examining the estimation results of land price gradients.

Regulatory Constraints and Open City Assumption

The most critical assumption in our analysis is that of a small open city. Only under this assumption is it possible to estimate correctly the optimal urban land area from the available data. This point is illustrated in Figure 3. The two diagrams display the impact of greenbelt regulations on the

[5]See [9] for criticism of the assumption and [11] for a model that deals with this issue.

[6]The nature of the problem arising from subcenter(s) is similar to the problem of topographical barriers discussed earlier. Two urban areas separated by a body of water but without a transportation link such as a bridge can be seen as two subcenters.

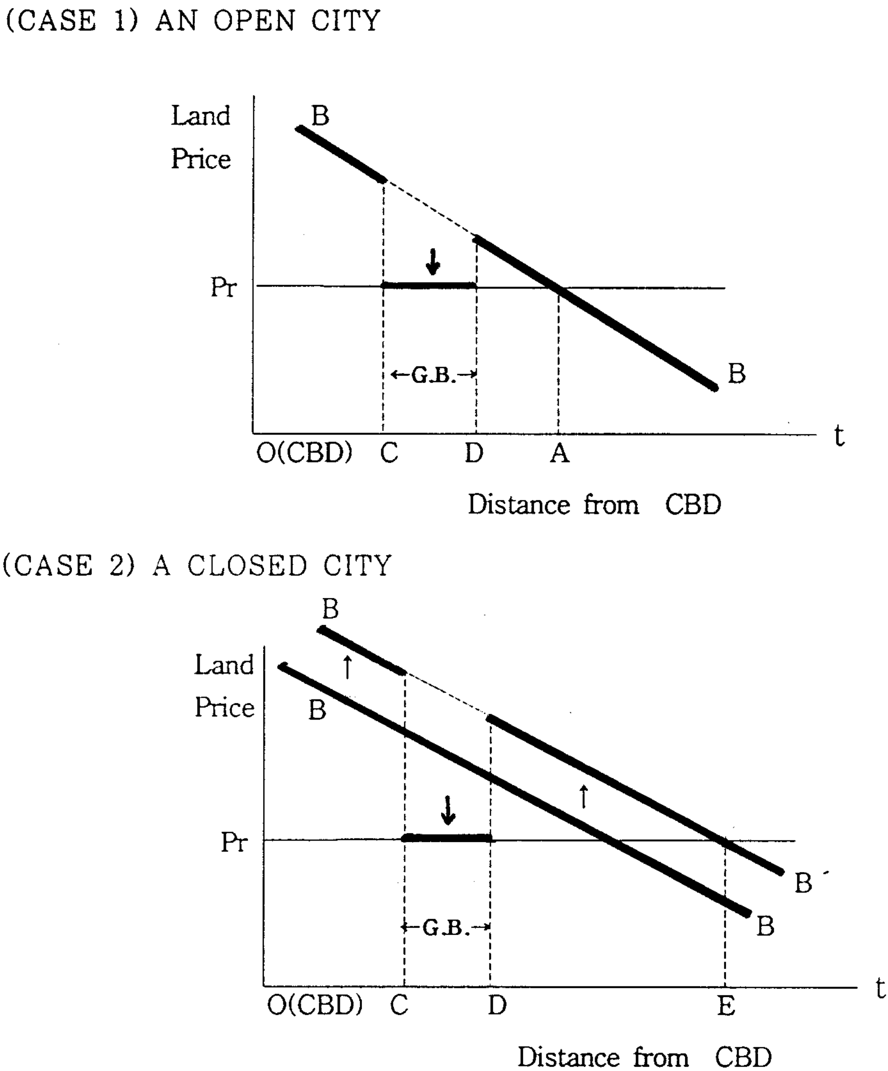

FIG. 3. Impact of introduction of green belt.

land price profiles for both an open city and a closed city. Greenbelt regulations in Korea override all other zoning regulations so that even plots zoned for urban use are subject to restricted development if they are located inside the belt. Naturally, prices of plots within the greenbelt are severely depressed. Suppose that a greenbelt is introduced between point

C and point D. In an open city, the supply of urban land will be restricted but the land price profile will not be affected. The reason is that the height of the land price curve is determined by the exogenously given level of residents' utility, which is not affected by the greenbelt. A new equilibrium will be obtained as some residents move out of the city. The true land price profile can be estimated by using a dummy variable, and the equilibrium quantity of urban land is correctly calculated.

On the other hand, the introduction of a greenbelt to a closed city will shift the land price function. Since population is fixed in a closed city, land price will have to rise at every location as depicted by $B'B'$ in order to induce everybody to consume a smaller amount of land than before. The available land price data will allow one to estimate curve $B'B'$ but not BB, and consequently the equilibrium quantity of urban land will be overestimated.

The small open city assumption affects the validity of our methodology at the empirical level. First of all, the model may not be appropriate for Seoul and other large cities, since they are certainly large and may even be closed in the sense that population size of such cities does not change easily. Second, the urban land shortage estimate in a city will be accurate only in a partial equilibrium context. One should therefore be warned against calculating the nationwide total shortage of urban land from our results.

III. EMPIRICAL ANALYSIS

1. *Data and Estimation Procedure*

Data

Our unit of observation is a city or a county. Although Seoul and five other largest cities consist of districts each having a population larger than that of most small cities, we treat these large cities as single entities because all districts comprise a single land market in the respective cities.

We constructed 171 city-level observations for which urban and rural land price gradients are estimated and optimal urban land area is measured. The data set used in our analysis contains the publicly posted land value on roughly 300,000 plots across the country appraised as of January 1, 1992. The sample represents approximately 2% of all land parcels in large cities, and about 1% in other cities. The price of each land parcel is the arithmetic mean of two independent appraisals carried out by certified appraisers. The data set also contains in-depth plot-specific information on the type of land use, distance from major public facilities, and many regulatory variables. The data identifies each plot by the 24 categories of current land usage. Plots described as agricultural and forestal land, pasture, and bodies of water are classified as rural, and the rest are classified as urban. In addition to residential, commercial, and industrial building sites, urban land includes such public property as roads, railways, parks, and plots for "miscellaneous use." Since the last category of plots may be used for either urban or rural purposes, we would be safer with a conclusion that urban land is in short supply.

Land Price Gradients

We estimate land price gradients like *BB* and *RR* in Figure 1 by fitting separate negative exponential land price gradients for urban and rural plots[7]:

$$\text{Log Pu} = a_0 + a_1 t + a_2 D + a_3 D \cdot t + u \tag{3}$$

$$\text{Log}\,(\text{Pr} + C) = b_0 + b_1 t + b_2 D + b_3 D \cdot t + v, \tag{4}$$

where Pu and Pr refer to the price of a plot measuring one square meter in urban and rural use, respectively. C is the cost of developing one square meter of non-urban land into urban land, and t represents the airline distance from the center of the city defined as the site of the city hall or the county administrative office. u and v are error terms. The dummy variable D intends to capture the effect of the greenbelt in which land development is virtually prohibited. The variable takes a value of 1 if a plot is located inside the greenbelt area and zero otherwise. As for the land development cost C, we borrowed the figure of 93,000 won per square meter from Chung-Ho Kim [3], who computed it from the cost data on the sites developed and serviced by the Korea Land Development Corporation, the dominant public sector developer. We assume that the development cost does not vary from city to city.

Calculation of the Equilibrium Amount of Urban Land

Since a land price gradient is represented by two critical parameters, slope and intercept, there are four possible types of allocation of land between urban and rural use. However, only three types were obtained in our empirical analysis as depicted in Figure 1. For each type, the equilibrium urban land area is calculated as follows.

Type 1. Type 1 represents the most realistic outcome in that the urban land price curve has both a steeper slope and a greater intercept than its rural counterpart ($|a_1| > |b_1|$ and $a_0 > b_0$). We set the greenbelt dummy variable equal to zero to find the unfettered equilibrium. Therefore,

[7] This may lead to selectivity bias. See [7] for an example of addressing the problem. Also refer to [6] for a discussion of limitations of the negative exponential functional form.

distance from the center to the equilibrium urban boundary A is determined by

$$A = (a_0 - b_0)/(b_1 - a_1) \tag{5}$$

Several adjustments are required since real world cities may not satisfy the standard assumptions of the model. In order to deal with cases such as cities with waterfront CBD, we first select the 2% of plots farthest from the center, and calculate the average distance (L) of those plots from the center. Then we compute the ratio r between the area of a circle with radius L and the actual land area within the legal boundary of the city, V:

$$r = \frac{\pi L^2}{V}. \tag{6}$$

If a city is circular in shape with its CBD located close to the center of the circle and there are enough observations near the boundary, then r will take a value close to 1. On the other hand, non-circular cities or cities whose centers are not at the center of the circle are likely to have an r which is greater than 1. Although it is conceptually impossible for r to be less than 1, several such cases were found in our sample due to insufficient observations near the boundary. In order to eliminate them, we define a topographical adjustment factor as

$$r^* = \text{MAX}\{1, r\}. \tag{7}$$

This leads to the equilibrium amount of urban land of a city which is equal to $\pi A^2/r^*$, but it must be adjusted to ensure that the computed value is less than the total land area V within its legal boundary,

$$U^* = \text{MIN}\{(\pi A^2/r^*), V\}. \tag{8}$$

Type 2. Type 2 refers to the case in which rural land price plus conversion cost exceeds urban land price in all locations ($|a_1| > |b_1|$ and $a_0 < b_0$). Since *BB* and *RR* intersect to the left of the origin ($A < 0$), we set the equilibrium amount of urban land U^* equal to zero. We interpret Type 2 as the situation in which no land should be devoted to urban use because of the high opportunity cost of urban land. All Type 2 cities have a surplus of urban land ($S > 0$ and $s > 0$).

Type 3. Type 3 is the case where *BB* lies above *RR* at all locations so that more than the whole land area of the city should be used for urban purposes in equilibrium ($|a_1| < |b_1|$ and $a_0 > b_0$). All Type 3 cities have a shortage of urban land ($S < 0$ and $s < 0$). Although this type can arise in highly urbanized cities where the development pressure overflows the city boundary, it can also occur because the city in question does not satisfy the assumptions of the model such as monocentricity or featureless topography. We set U^* equal to V.

2. *Estimation Results*

(1) *Land Price Gradients*[8]

For most cases, the estimated coefficients of Eqs. (3) and (4) exhibited expected signs. The intercept terms a_0 and b_0 were positive and statistically significant for each of the 171 cities. The slope coefficient of the urban land price function a_1 was negative for all but two of the satellite cities of Seoul. Although the result may imply that the center of economic activity of these two cities is Seoul rather than the sites of their own city halls, the positive coefficients were statistically insignificant. The coefficient for the greenbelt dummy a_2 took on a significant negative value for all six largest cities and most other major cities. The R-square value ranged from 0.02 to 0.70, that of Seoul being 0.07. Perhaps the land price structure of Seoul and some other cities is much more complex than what the standard monocentric city model predicts, and physical distance from the center does not matter much. The slope coefficient for the non-urban land function b_1 carried a negative sign for all but seven cities, and only two of the seven cases of positive b_1 were statistically significant. By comparing a_0 with b_0 and a_1 with b_1, we classified our sample of 171 cities and counties into three types: 115 observations fell into Type 1; 50 counties, all located in rural areas, into Type 2; and the remaining six cities and counties, which are either satellite cities of Seoul or have large-scale industrial or resort complexes outside the city center, were Type 3.

Table 1 presents the estimated coefficients averaged over groups classified by province and by type. Figures reported in the second and third column of the table display a substantial variation in the coefficients of urban land price gradients across regions. The intercept was largest in Seoul, followed by the next five largest cities, Kyunggi Province, which surrounds Seoul, and then by the most popular resort island, Cheju Province. One square meter of urban land in central Seoul is worth 63 times more than that in the average city of North Cholla Province, which has the smallest average intercept. The average of slope coefficients ranged from -0.023 to -0.490, those of the largest cities being much smaller in absolute value than those of smaller cities. The smaller slope coefficient found in large cities reflects low transportation costs mainly due to better transportation networks, and large size of urban economy.

Rural land price curves are much less steep than urban land price functions, confirming that accessibility to the center is less valuable for

[8] City-by-city estimation results are available to interested readers from the authors.

TABLE 1
Means of Estimated Coefficients of Land Price Gradients: By Region and Type

	No. of cities	a_0	a_1	b_0	b_1
By Region					
Seoul	1	14.4	−0.027	12.9	−0.024
Pusan	1	13.8	−0.023	12.1	−0.020
Taegu	1	14.0	−0.137	12.9	−0.129
Inchon	1	13.5	−0.048	12.2	−0.022
Kwangju	1	13.8	−0.290	13.3	−0.105
Taejeon	1	13.3	−0.105	11.8	−0.057
Kyunggi	32	12.55	−0.276	11.42	−0.074
		(1.25)	(0.189)	(0.970)	(0.193)
Kangwon	18	11.07	−0.400	10.59	−0.042
		(1.21)	(0.167)	(0.460)	(0.075)
North Choongchung	10	11.10	−0.490	10.51	−0.027
		(0.902)	(0.141)	(0.191)	(0.012)
South Choongchung	16	10.94	−0.477	10.58	−0.033
		(1.00)	(0.156)	(0.191)	(0.017)
North Cholla	14	10.26	−0.407	10.51	−0.021
		(1.48)	(0.192)	(0.306)	(0.036)
South Cholla	25	10.50	−0.407	10.56	−0.031
		(1.40)	(0.167)	(0.348)	(0.041)
North Kyungsang	25	11.23	−0.489	10.53	−0.030
		(1.11)	(0.156)	(0.239)	(0.034)
South Kyungsang	23	11.37	−0.422	10.60	−0.031
		(1.34)	(0.222)	(0.284)	(0.032)
Cheju	2	12.50	−0.261	10.70	−0.014
		(0.99)	(0.165)	(0.000)	(0.021)
Six large cities	6	13.80	−0.105	12.32	−0.061
		(0.385)	(0.101)	(0.471)	(0.049)
Nine provinces	165	11.28	−0.405	10.73	−0.039
		(1.41)	(0.189)	(0.605)	(0.093)
Whole country	171	11.37	−0.394	10.78	−0.040
		(1.47)	(0.195)	(0.667)	(0.092)
By Type					
Type 1	115	11.99	−0.420	10.86	−0.037
		(1.14)	(0.203)	(0.628)	(0.064)
Type 2	50	9.73	−0.360	10.4	−0.015
		(0.543)	(0.146)	(0.106)	(0.012)
Type 3	6	13.17	−0.173	12.47	−0.310
		(0.942)	(0.232)	(1.00)	(0.310)

Note: Standard deviations are given in parentheses.

rural activities than for urban ones. Inter-regional variation of intercepts and slope coefficients is small compared to that of urban land price functions. As was true of urban land price functions, six large cities and Kyunggi Province have higher intercepts than other provinces, indicating that the prospect of land use change is already reflected in the price of rural land. One should note, however, that rural land hypothetically at the center of Seoul would be only 10.9 times as expensive as its counterpart in North Cholla Province compared with the ratio of 63 reported above for urban land prices.

Among the six largest cities, the slope of the non-urban land price curves is quite small for Seoul, Pusan, and Inchon, while the slope for the remaining three is relatively large. The magnitude of the average slopes for the provinces falls in-between. We do not have a convincing explanation for the large variation of slope coefficients among the six large cities, but it is interesting to note that the difference in the average slope coefficients between urban and non-urban functions is much larger in the provinces than in the six large cities. This implies that the smaller cities in these provinces have an economy which requires only small land areas. Finally, among the provinces, with a possible exception of Cheju Province, the average of intercepts of both urban and rural land price gradients varies little, and the standard deviation of intercepts is only about one-tenth of the average. This indicates that the price of urban land (and hypothetical rural land as well) at the center is similar among small cities across the country. It also implies that the size of urban economy in small cities may be more or less uniform across the country.

(2) *Shortage or Surplus of Urban Land*

Table 2 summarizes the status of urban land shortage/surplus for the three types of cities identified earlier.[9] The table shows that urban land is

[9] Estimates for urban land shortage/surplus measures for all cities can be provided to interested readers from the authors.

TABLE 2

Distribution of Cities According to Estimated Land Shortage or Surplus

	Shortage ($s < 0$)				Surplus ($s > 0$)		
	500% +	300 ~ 500%	100 ~ 300%	0 ~ 100%	0 ~ 50%	50 ~ 99%	99 ~ 100%
Type 1	10	11	19	14	16	31	14
Type 2	0	0	0	0	0	0	50
Type 3	4	2	0	0	0	0	0
Total	14	13	19	14	16	31	64
Cumulative	14	27	46	60	76	107	171

in shortage in 60 out of 171 cities. They represent 35% of the total sample. In these cities, the difference between urban land price and non-urban land price is so large relative to the cost of conversion that much more land should be used for urban purposes. In particular, estimated land shortages in 21 cities exceeded three times the amount of land in current urban use. On the other hand, in many other cities, it makes little economic sense to convert non-urban land into urban use. A total of 111 cities (61 Type 1 cities and all Type 2 cities), or 65% of the entire sample, falls in this category.

Table 3 reports shortage and surplus figures by region. It shows that the shortage of urban land is severe in the six largest cities. With an exception of Seoul, estimated urban land shortages were larger than the total of land currently being used for urban purposes in these cities. Although the open-city assumption is probably not appropriate for these large cities, our qualitative conclusion—that all land currently used for non-urban purposes can be profitably converted to urban use—should be upheld. This may not necessarily mean that all non-urban land should be converted into urban use, since farms and forests may generate positive externalities which cause the social value of non-urban land use to deviate from the market price.[10] At the moment, the safe conclusion should be that since the development pressure is high in these cities, growth reaching beyond the city boundaries is necessary.

In the case of 165 cites located in 9 provinces, the average shortage of urban land was 68% of the amount in urban use. However, a very large variation was observed across provinces in terms of urban land shortage/surplus estimates. On average, cities in Kyunggi province surrounding Seoul suffer most from urban land shortages (about 340% of land in current urban use), followed by Cheju Island and South Kyungsang Province surrounding Pusan, the second largest city. On the other hand, Cholla and Choongchung provinces as well as North Kyungsang Province exhibited urban land surpluses. As a whole, 171 cities studied reported a shortage of urban land averaging at 145% of land currently being used for urban purposes.

[10]A careful cost–benefit analysis would be ideal for this reason. A recent study by Lee [5, p. 114] reports that release of urban land located within the 100-meter radius from the inner edge of Seoul's greenbelt would have generated a net social welfare gain worth almost 4 trillion won in 1989 ($1 = 680 won).

TABLE 3
Means and Standard Deviations of Estimated Urban Land Shortage or Surplus Measures by Region

Region	No. of cities	V	U	U^*	$S = U - U^*$	$s = \frac{U - U^*}{U} \times 100$
Seoul	1	605.3	321.7	605.3	−283.6	−88.15
Pusan	1	529.4	151.2	529.4	−378.2	−250.02
Taegu	1	455.7	111.9	455.7	−343.8	−307.35
Inchon	1	317.2	108.8	317.2	−208.4	−191.47
Kwangju	1	500.9	78.6	319.7	−241.1	−306.86
Taejeon	1	537.2	75.3	537.2	−461.9	−613.25
Kyunggi	32	336.7	23.3	73.4	−50.1	−339.79
		(284.8)	(16.8)	(96.0)	(97.9)	(521.80)
Kangwon	18	938.8	21.5	21.1	0.4	−31.82
		(500.8)	(9.8)	(32.5)	(32.6)	(278.04)
North Choongchung	10	743.6	28.8	25.8	3.0	52.55
		(213.8)	(17.6)	(60.9)	(44.9)	(82.60)
South Choongchung	16	516.1	26.0	5.0	21.0	77.24
		(178.0)	(6.7)	(7.1)	(10.3)	(39.95)
North Cholla	14	574.5	27.2	7.8	19.4	78.96
		(216.7)	(12.5)	(21.4)	(17.1)	(49.34)
South Cholla	25	472.5	23.5	12.3	11.2	28.51
		(224.6)	(8.1)	(28.5)	(31.6)	(149.89)
North Kyungsang	25	777.9	24.6	18.9	5.7	12.70
		(368.9)	(13.9)	(30.8)	(25.7)	(157.63)
South Kyungsang	23	511.9	25.2	92.1	−66.9	−144.03
		(288.0)	(16.6)	(234.7)	(220.9)	(400.97)
Cheju	2	912.8	67.3	164.1	−96.8	−147.69
		(66.3)	(11.2)	(4.5)	(15.7)	(47.77)
Six large cities	6	490.9	141.3	460.7	−319.5	−292.85
		(98.2)	(92.6)	(120.0)	(93.9)	(177.24)
Nine provinces	165	583.4	25	38.8	−13.8	−67.62
		(355.5)	(14.1)	(104.8)	(100.0)	(333.68)
Whole country	171	580.2	29.1	53.6	−24.5	−75.52
		(349.9)	(30.0)	(130.7)	(114.4)	(331.76)

Note: Standard deviations are given in parentheses.

IV. FACTORS DETERMINING SHORTAGE OR SURPLUS OF URBAN LAND

1. *The Model*

Naturally emerging from our calculation of optimal urban land area and shortage/surplus measures is the question of how the shortage/surplus of urban land is related to city-specific traits. This section seeks to answer this question by regression analyses. Specifically, we are interested in testing the hypothesis that urban land shortage in Korea results from government regulations which restrict land development and supply. This can be done by regressing a measure of urban land shortage against explanatory variables representing natural and regulatory constraints and other variables. The hypothesis can be justified if the regulatory variables carry a significant sign.

The small-and-open city assumption which justifies our measurement of urban land shortage/surplus also determines the structure of the regression equation. Under this assumption, the position of the bid price function is determined by the economic conditions of the system of cities to which an individual city belongs, rather than by city specific demand factors. Therefore, the magnitude of urban land shortage/surplus of an individual city is explained only by supply side factors such as natural and contrived restrictions on land use and development. If the assumption fails, both demand and supply factors would affect the land shortage/surplus measure, so that the measure developed in this study may not be correct. Whether a city is "open" or "closed" is an empirical issue, and clear-cut classification is not always possible. We thus present both sets of regression results: one without demand variables and the other with them.

We have also noted that estimated land shortage/surplus figures for the six largest cities, Type 3 cities, and those in the Capital region may suffer from measurement problems, in part because they are likely to be closed cities. In order to secure robust results from our regression analysis, we form three different samples by successively eliminating such cities. Sample 1 is composed of all 171 cities, but Sample 2 takes out the six largest cities and Type 3 cities. Sample 3 further omits all cities in the Capital region. By estimating separate regressions on these three samples and comparing the results, we will be able to obtain stable conclusions and further insights as to how characteristics of the city affect the shortage/surplus measure.

2. *Variables*

Each regression equation has the shortage/surplus measure s (in percentage units) as the dependent variable. An increase in s means that urban land surplus increases or its shortage decreases, and vice versa. Explanatory variables can be grouped as follows:

Natural Land Use Constraints

Topography and other natural conditions may constrain land development and hence the supply of urban land. If the land has a steep grade, development can be impossible or costly. Mountains, islands, and bodies of water also restrict urban land supply. We use two variables to capture such constraints. One is the ratio of the area of forestal land and rivers to the total land area of the city, N1. Data on grade would be preferable, but they are not available and one can reasonably assert that most forestal land in Korea remains undeveloped because its geographical traits are unfavorable for development.[11] The other variable which represents natural constraints is a dummy variable N2 which is 1 if the city has inhabited island(s) larger than 10 km^2 and 0 otherwise. This variable is not very satisfactory since it cannot fully describe the conditions of cities containing islands in their jurisdiction, but data availability precludes the use of better alternatives. Greater values of N1 and N2 are expected to decrease s.

Contrived Land Use Constraints

Restrictive regulations on land development and land use limit the supply of urban land as much as, if not more than, the natural constraints in Korea. Over 70 laws restrict or facilitate land development in certain zones and districts. The most stringent type of land use control is implemented on land inside the greenbelt.[12] Therefore we chose to include GBELT, the ratio between the greenbelt area and the total land area of a city, as our regulatory variable. A higher value for it will lead to a smaller value for s.

Infrastructure

Roads, bridges, tunnels, and other physical infrastructure help overcome natural land use constraints and facilitate urban land supply. As measures of infrastructure services, we use road length (km) per square kilometer of land area, I1, and local government total revenue per 1000 residents, I2. The latter includes central government transfers, some of which is earmarked to infrastructure investment projects. These variables are expected to increase s.

Demand Side Factors

In regression equations which include demand side variables, population (POP91) and the rate of population increase for the past three years (RPI) are used to reflect the demand conditions for urban land. In order to capture the level of economic activities, the output of manufacturing and mining sectors (IN1) and the local government's revenues from own sources (IN2) are also included in the equation. These variables are expected to decrease s.

[11] Since conversion of forestal land into urban land is restricted also by regulations, N1 may reflect the contrived restriction on urban land supply to some extent. However, the regulation is less severe than in the case of agricultural land, which usually does not have topographical problems for development.

[12] See [4] or [5] for details.

Regional Dummies

Regional dummy variables are included to see if regional peculiarities affect urban land shortage/surplus. Following the traditional regional grouping used in Korea, the six largest cities and nine provinces are classified into four regions.[13] Coefficients of RG1, RG2, and RG4 represent difference in s of the Capital region, the Central region, and the Southeastern region compared to the Southwestern region, whose economy is relatively backward.

Definitions of all variables and their summary statistics are presented in Table 4.

3. *Estimation Results*

Estimated values of the coefficients of two sets of regression equations are reported in Table 5 for each of the three samples described above. Figures in column (1) are from the equation which has only supply side factors as explanatory variables, and those in column (2) represent estimates of regression equations which include demand side variables as well.

The estimation results more or less support the hypothesis that only government regulation can cause urban land shortages. Neither of two variables for natural land use constraints proved significant at the 10% level. Although N1 has fairly large *t*-values and expected (−) signs, natural constraints do not appear to be an important factor in explaining the urban land shortage/surplus in Korea. On the other hand, the regulatory variable GBELT exhibited a significant negative coefficient in five of six cases. This appears to be a strong proof that regulations are at the root of the urban land shortage problem in Korean cities. It is also interesting to note that the estimated coefficient of GBELT is much smaller in Sample 3 than in the entire sample and Sample 2. It can be interpreted as implying that the greenbelt regulations have a binding impact mostly on the cities in the Capital region and the six large cities.

There are a few cases where the sign of the coefficient differed from our expectation. Although infrastructure variable I2 had a positive sign in all six cases (only two being significant), the other infrastructure variable I1 exhibited a significant negative coefficient in sub-sample 3 contrary to the expectation that increased accessibility opens up prospects for development and decreases the shortage of urban land. This may be indicative of the infrastructure investment practice by which roads are built in order to alleviate congestion in cities where the land use is already predominantly

[13] They are the Capital region (Seoul, Inchon, and Kyunggi Province), the Central region (Taejeon, Kangwon Province, and North and South Choongchung provinces), the Southeastern region (Pusan, Taegu, and North and South Kyungsang provinces), and the Southwestern region (Kwangju, North and South Cholla provinces, and Cheju Province).

TABLE 4

Summary of Variables Used in Regression

Variable category	Variable	Content	Sample mean (Standard deviation) sample 1 (171 cities)	sample 2 (159 cities)	sample 3 (131 cities)
<LHS variable>	s	Ratio of urban land shortage/surplus (S) to land in actual urban use (in %)	−75.52 (331.76)	−42.44 (307.41)	9.01 (207.08)
<RHS variable>					
Natural land use	N1	Ratio of forestal land and river to total land area (V)	0.592 (0.189)	0.598 (0.191)	0.612 (0.193)
constraint	N2	1 if the city contains island(s) larger than 10 km^2, 0 otherwise	0.099 (0.300)	(0.094) (0.293)	0.099 (0.300)
Contrived land use constraint	GBELT	Ratio of green belt area to V	0.097 (0.208)	0.068 (0.167)	0.0352 (0.100)
Infrastructure	I1	Length of road (km)/V	0.788 (1.18)	0.640 (0.729)	0.528 (0.380)
	I2	Local government total revenue per 1000 residents (mil. won)	309.3 (143.2)	316.3 (143.6)	331.2 (130.7)
Population	RPI	Rate of population increase during 1988–91	0.0025 (0.536)	−0.0031 (0.555)	−0.066 (0.171)
	POP91	Population at the end of 1991 (1000 persons)	266.9 (917.1)	150.4 (211.2)	123.7 (119.3)
Industrial activity	IN1	Manufacturing and mining production (bil. won per 1000 residents)	2.40 (3.88)	2.26 (3.87)	1.85 (3.75)
	IN2	Local government own revenue (mil. won per 1000 residents)	119.6 (62.7)	116.3 (59.97)	113.4 (59.1)
Region	RG1	1 for cities in the Capital region, 0 otherwise	0.199 (0.400)	0.176 (0.382)	—
	RG2	1 for cities in the Central region, 0 otherwise	0.263 (0.441)	0.270 (0.446)	0.328 (0.471)
	RG3	1 for cities in the Southwestern region, 0 otherwise	0.246 (0.432)	0.258 (0.439)	0.313 (0.465)
	RG4	1 for cities in the Southeastern region, 0 otherwise	0.292 (0.456)	0.296 (0.458)	0.359 (0.481)

Sources: Ministry of Home Affairs, *Statistics of Land Record*, 1991; Ministry of Home Affairs, *Yearbook of Local Public Finance*, 1991; Bureau of Statistics, *Regional Statistics Yearbook*, 1991; Ministry of Construction, *Construction Statistics*, 1992.

TABLE 5
Results of Regression

RHS variables	Sample 1 (171 cities) (1)	Sample 1 (171 cities) (2)	Sample 2 (159 cities) (1)	Sample 2 (159 cities) (2)	Sample 3 (131 cities) (1)	Sample 3 (131 cities) (2)
Constant	73.86	75.88	11.64	123.06	187.89*	313.36**
	(0.76)	(0.78)	(0.11)	(1.21)	(2.25)	(4.24)
N1	−162.71	−197.94	−97.61	−143.69	−58.49	−82.06
	(−1.29)	(−1.64)	(−0.78)	(−1.21)	(−0.64)	(−1.09)
N2	−23.84	−5.44	−37.22	−24.39	−39.15	−21.92
	(−0.32)	(−0.07)	(−0.48)	(−0.33)	(0.70)	(−.47)
GBELT	−725.30**	−630.62**	−671.75**	−604.93**	−398.88*	−119.58
	(−5.88)	(−5.23)	(−4.37)	(−4.05)	(−2.28)	(−0.78)
I1	15.09	47.91	25.52	74.81*	−186.52**	−102.19*
	(0.73)	(1.41)	(0.72)	(2.12)	(−3.82)	(−2.44)
I2	0.24	0.79**	0.30	0.47 ^	0.058	0.022
	(1.44)	(3.39)	(1.83)	(1.91)	(0.49)	(0.12)
RG1	−183.11*	−109.14	−194.89**	−149.62*		
	(−2.58)	(−1.55)	(−2.72)	(−2.09)		
RG2	−42.74	17.14	−14.30	7.87	−28.37	3.31
	(−0.69)	(0.28)	(−0.23)	(0.13)	(−0.67)	(.089)
RG4	−69.49	−16.62	−72.70	−34.16	−102.30*	−58.74
	(−1.15)	(−0.28)	(−1.21)	(−0.59)	(−2.45)	(−1.65)
POP91		−0.01		−0.52**		−0.76**
		(−0.43)		(−2.83)		(−5.42)
RPI		13.92		157.31*		71.76
		(0.33)		(2.38)		(0.76)
IN1		−5.90		−8.35		−9.94*
		(−0.91)		(−1.23)		(−2.17)
IN2		−1.80**		−0.86		−0.56
		(−3.60)		(−1.50)		(−1.55)
R^2	0.345	0.428	0.287	0.380	0.257	0.516

Notes: *t*-statistics are given in parentheses. The symbols **, *, and ^ stand for significance at 1%, 5%, 10% level, respectively.

urban rather than to encourage the development of the cities where conversion of rural land is desired. Due to a lack of other alternatives, economic activities are concentrated in those cities which have better road conditions and high premiums for urban land. If this interpretation is correct, the negative sign does not deny the importance of infrastructure investment in urban land supply.

Regional dummies clearly show that cities in the Capital and Southeastern regions tend to have a greater shortage of urban land than cities in the Southwestern and Central regions, but we are not sure if this is due to supply side or demand side factors. On the supply side, the Capital region is subject to the Capital region growth control measures, in addition to the greenbelt regulation and other nationwide land use regulations. Cities around Pusan and Taegu in the Southeastern region also have extensive greenbelts. On the demand side, industrial, financial, administrative, and other urban activities are highly concentrated in the two regions.

The null hypothesis that all demand side variables jointly have no impact on the shortage of urban land was rejected by an F-test at 1% level of significance in all three samples. Individually, the rate of population increase RPI has a positive coefficient, and population size POP91 has a negative coefficient. The former runs contrary to our expectation, but the magnitude is too small to be meaningful. While the latter is consistent with our expectation, the coefficient is not significant in one out of three cases. Industrial production IN1 in general shows negative signs with fairly large t-values. The coefficient is especially large and significant at the 1% level for Sample 3. It indicates that the urban land supply is not meeting the demand for industrial development in small cities. Local government own revenue IN2 is negative and significant for Sample 1, but is not significant for Sample 3.

These results have at least two policy implications. First, land use regulations rather than natural conditions are the main problem in urban land supply. Removing the artificial constraint should be a preferred alternative in meeting the demand for urban land necessary to facilitate economic development and improve urban housing conditions. Second, infrastructure investment may be late and insufficient. Forward-looking physical planning will be necessary for forecasting the future and meeting the demands before bottlenecks build up.

V. CONCLUDING REMARKS

The main objective of this study was to derive measures of shortage or surplus of urban land from the standard urban model and to provide estimates of the measures for Korean cities. For each of 171 cities, we estimated urban and non-urban land price gradients and used the estimates to compute the equilibrium amount of urban land, paying due attention to urban topography. We then calculated urban land shortage/surplus and found that 60 out of 171 cities have shortages whereas the remaining 111 cities have surpluses. The shortages appear to be most serious for the six largest cities and cities in Kyunggi Province.

The model we used to estimate the shortage and surplus of urban land in Korean cities is based on a set of assumptions, some of which could be challenged on conceptual and empirical grounds. Most importantly, severe land shortages found in large cities may be interpreted as rejecting the monocentric model and having nothing to say about land shortage/surplus situations.[14] Although we have tried to rectify some of the potential problems, it is difficult to tell to what extent they have affected the accuracy of our estimation. On the other hand, we believe that our study perhaps represents the first serious attempt to apply the land price data to measure the size of discrepancy between optimum and actual amount of urban land.

We also investigated the determinants of shortage/surplus of urban land. Our results suggest that land use regulations such as greenbelt are the dominant cause of urban land shortages. This has an obvious policy implication that land use regulations should be relaxed in order to satisfy the increasing demand for urban land and stabilize land prices in Korean cities.

Some variables turned out to affect the magnitude of urban land shortage/surplus in ways which are different from our expectations. We also found that the some demand side variables have a significant effect on the urban land shortage/surplus, contrary to the implication of the small-and-open city assumption. An analysis of the mechanisms for such interaction would be a topic for further research.

[14] A different model of multiple centers would be more appropriate for Seoul and satellite cities as was pointed out by a referee. Unfortunately, however, our data set did not contain distance to downtown Seoul from plots located in satellite cities.

REFERENCES

1. J. K. Brueckner, The structure of urban equilibria: A unified treatment of Muth–Mills model, *in* "Handbook of Regional and Urban Economics," Vol. II (E. S. Mills, Ed.), North Holland, New York (1987).
2. L. M. Hannah, K.-H. Kim, and E. S. Mills, Land use controls and housing prices in Korea, *Urban Studies*, **30**, 147–156 (1993).
3. C.-H. Kim, *Land Use Regulations in Korea*, Korea Economic Research Institute, Seoul (1994). (In Korean.)
4. K.-H. Kim, Housing prices, affordability, and government policy in Korea, *Journal of Real Estate Economics and Finance*, **6**, 55–71 (1993).
5. C.-M. Lee, "Greenbelt Impacts on Dynamics of a Physical Urban Development and Land Market: A Welfare Analysis—The Case of Seoul's Greenbelt," unpublished doctoral dissertation, University of Pennsylvania, Philadelphia (1994).
6. J. F. McDonald, Econometric studies of urban population density: A survey, *Journal of Urban Economics*, **26**, 361–385 (1989).

7. D. P. McMillen and J. F. McDonald, Urban land value functions with endogenous zoning, *Journal of Urban Economics*, **29**, 14–27 (1991).
8. H. O. Pollakowski and S. M. Wachter, The effects of land-use constraints on housing prices, *Land Economics*, **66**, 315–324 (1990).
9. H. W. Richardson, Monocentric vs. policentric models: The future of urban economics in regional science, *Annals of Regional Science*, **22**, 1–12 (1989).
10. L. A. Rose, Topographical constraints and urban land supply indexes, *Journal of Urban Economics*, **26**, 325–345 (1989).
11. J. Yinger, Urban models with more than one employment center, *Journal of Urban Economics*, **31**, 181–205 (1992).