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QUANTITY PREMIUM IN REAL PROPERTY MARKETS

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ABSTRACT

Using land market data in residential districts of Osaka Metropolitan Area in 1993, we tested the theory of nonlinear pricing. It was shown that quantity premiums prevail in real property markets, i.e., higher unit land prices for greater consumption of land is observed unlike in many commodity markets. We demonstrated that this is due to the irreversibility in changing lot size, the oligopolistic market structure, nondecreasing marginal utility, and/or nondecreasing returns to scale in production.

JEL codes: C21, L13, R21

1. Introduction

In many cities, some districts are planned with wide and straight roads whereas other districts are planlessly developed with narrow and twisted roads. The population density in the former is usually lower than that in the latter. Which districts are more desirable for society? From an aesthetic point of view, there is no doubt that the former districts are more desirable than the latter. For society as a whole, wide roads and large lot size in planned districts are desirable in that they ensure good exterior environments, relieve traffic congestion, and so on. That is why the necessity of city planning such as land use regulations and land readjustment projects is widely recognized.

However, city planning does not always meet the interests of landowners since having wide roads implies a reduction in their lot size. In general, given a total area, landowners prefer a larger area of lots and a smaller area of roads, usually leading to a decline in the overall environmental value. This is so–called the negative externalities generated by self–interested behavior of individual landowners.

While each lot size is great in the case of no planning regulations, the land price per unit area must be low as compared to planned one because of the difference in open space of roads. And so, it is ambiguous if the aggregate value of land is higher in planned districts than that in unplanned districts. Suppose that the benefits of environmental characteristics are fully capitalized by the land price as is often assumed in the literature of hedonic theory. Suppose further that the costs of land improvements and road construction are constant. Then, a social welfare would be measured by the aggregate land price of the whole district. For example, if the aggregate land price in a planlessly developed district is higher, then we may say that unplanned districts are more desirable and that an efficient allocation of land can be achieved by market mechanism without city planning by public authorities.

If we had detailed data on land price and lot size of each lot, we could calculate the aggregate land value in each district, enabling us to answer the question raised above. Unfortunately, due to lack of such fine data, we cannot give a direct answer, but in this paper we partly get an answer of the question by an indirect method.

The organization of the paper is as follows. In Section 2, we state a developer's problem of determining lot sizes. In Section 3, we conduct an empirical analysis to get an answer for it by using land price data in Osaka Metropolitan Area. In Section 4, we discuss on the results obtained in our analysis of the land market as well as in the literature on condominium markets. In Section 5, we make an attempt to explain the results using theories of nonlinear pricing in a differentiated product market. Section 6 concludes the paper.

2. Optimization of lot sizes by a developer

To simplify the argument posed in the previous section, consider a situation that all the lots in a district is owned by a single developer. In selling lots, he would subdivide or assemble them such that the aggregate value of the lots is maximized. In conventional theory of urban economics à la Alonso (1964), the optimal lot size in each location is determined mainly by the distance from the central business district (CBD) if there is no indivisibility problem and institutional constraints. And so, the lot size would exhibit geographical regularities: a monotonic increase in the (time) distance from the CBD; and no mixture of different lot sizes at the same distance from the CBD.

However, things are not so simple in the real world especially in cities having long history. In Japanese cities, for example, the lot size distribution, which is a reciprocal of the household density distribution is never monotonic geographically. It varies even within a small area according to local conditions. It is commonly observed in Japanese large cities that high rise apartment houses are located next to detached houses. Such a housing mixture is a result of historically cumulative development processes under myopic foresight by developers and landowners with housing durability (Harrison and Kain, 1974). Given uncertain factors in the future land markets, perfect foresight behavior is not always possible, which has resulted in uneven sizes of land lots.

Admittedly, the historical cities are quite different from the cities envisioned in urban economic theory. It is, however, short–circuited that the difference between reality and theory is simply ascribed to the myopic foresight behavior of developers and landowners together with the durability of buildings. Although developers do not perfectly foresee the future, they are not so totally myopic insofar as the amount of land is scarce and the price of land is very high. There must exist other factors determining the lot size, which we seek in the subsequent analysis of this paper.

In deciding the optimal lot size, the profit–maximizing developer would carefully observe the market demand for land:

$$p = f(s, \underline{x}), \tag{1}$$

where p is the price of lot i per unit area, s is the lot size, and $\underline{x}$ is a vector of other attributes such as access to the CBD, amenity, local environments, and so forth. Provided that the specification of (1) is correct, the developer can measure the marginal effect of lot size on the price of unit land ($\partial p/\partial s$), controlling the set of locational attributes $\underline{x}$.

That is, if $\partial p/\partial s$ is positive, the price of unit land is larger for a larger lot in the land market, which is called *quantity premiums.* In this case, the developer would attempt to maximize the lot size, and never subdivide any lot. He would assemble contiguous lots as many as possible. If $\partial p/\partial s$ is negative, on the other hand, the unit price decreases with lot size, which is called *quantity discounts.* The developer would subdivide the lots until they reach the minimum lot size.

In either case, ignoring the indivisibility problem, the currently existing lot size must be a maximizer of unit and total land price (Asami, 1993): [i] each lot size should be maximized when the price of unit land is increasing ($\partial p/\partial s>0$); and [ii] each lot size should be minimized when the price of unit land is decreasing in the lot size ($\partial p/\partial s<0$). An empirical test on the sign of $\partial p/\partial s$ is conducted in the next section.

3. Empirical analysis of the land market

Based upon the foregoing, let us conduct an empirical analysis of equation (1) in order to test whether quantity discounts or quantity premiums prevail in the land market. Since the lot size s is considered to be a quantity variable in land markets, we pay attention especially to the impact of the lot size on the unit land price p.

After some trial and error, we decided to specify the function f as the following semi–logarithm form:

$$\log p_i = a_0 + a_1 s_i + \sum_{k=2}^{K} a_k x_{ki} + e_i \quad \textit{for } i=1,..,I, \tag{2}$$

where a_k (k=0,...,K) are parameters to be estimated statistically, K is the number of independent variables, x_k's are the independent variables, e is the residual, I is the number of observations, and subscript i is added to each variable for the sake of statistical analysis. Since $\partial p/\partial s = a_1 p$, we test statistical significance on the sign of a_1, and conclude in the following way:

if $a_1<0$, quantity discounts prevail in the land market;

if $a_1>0$, quantity premiums prevail in the land market.

We used *kōji chika* (officially posted land prices) for the land prices p [in thousand yen per m^2] in residential districts of Osaka Metropolitan Area in 1993 (Japan Land Agency, 1993). It also contains the site–specific data such as the lot size s [in m^2] and the distance from the lot to the nearest railroad station x_2 [in m]. Data on the total minutes from the nearest station to the CBD of Osaka x_3 [in minutes] are calculated by the minutes needed by using the fastest commuter trains with train changing (if any) time of five minutes.

These data are collected along six commuter railroads starting from the CBD of Osaka: Keihan Line, JR Katamachi Line, JR Hanwa Line, Nankai Line, Kintetsu Osaka Line and Kintetsu Nara Line. Summary statistics are given in Table 1. We know from the statistics that each variable is within a certain range since each standard deviation is not so large, and that the average value of land prices is much higher and the average lot size is much smaller than an international level. Put it differently, Osaka Metropolitan Area is densely inhabited, and its land market is of paramount importance. Since the first two lines are running close and parallel with each other, we ran a regression together using a dummy variable. The same is true for the second two lines and the last two lines. We also ran a regression using all six lines using five dummy variables.

The result is summarized in Table 2.[1] Generally speaking, we got a good fit: the values of the regression coefficients in the first three cases are similar, and the t statistics of all coefficients are large. Most of the regression coefficients are significant at the 1% level, and the values of R^2 (between log p and its estimate, and between p and its estimate) are sufficiently large. This would justify not only our specification of equation (2), but also our choice of the six lines. In other words, we may say that (the logarithm of) the land price along these lines can be explained only by the few variables: the access to the CBD and the lot size.

Observing the sign of a_1 (the first row in Table 2), we do recognize that it is positive and statistically significant at the 1% level (Keihan–Katamachi Lines, Kintetsu Osaka–Nara Lines, and all six Lines) or at the 5% level(Hanwa–Nankai Lines). These results do support *the quantity premium hypothesis in the land market.*[2] This exhibits a clear contrast to various markets of consumption goods, where quantity discounts are common practices: apples are often sold like one for 100 yen and three for 200 yen. We discuss the reasons for the opposite conclusion in the following sections.

Before the discussion, we should mention two points to notice. The first point is an econometric problem of multicolinearity between the independent variables in equation (2). According to the theory of urban economics, both the land price p and the lot size s are determined mainly by the distance from the CBD.[3] If this were to be true, s would be correlated with the distance to the station x_2 and/or the time (distance) to the CBD x_3, which would invalidate our specification, and hence our analysis itself.

So as to check this problem, we computed the correlation coefficients between the lot size s and the total time from the lot to the CBD $(a_2/a_3)x_2+x_3$, using the estimates of a_2 and a_3 in Table 2. The value of respective correlation coefficients are: 0.237 in Keihan–Katamachi Lines, 0.167 in Hanwa–Nankai Lines, and 0.093 in Kintetsu Osaka–Nara Lines. The corresponding t statistics to each correlation coefficient are: 2.56, 2.17, and 1.19 respectively. The first two values are statistically significant at the 5% level, but not at the 1% level whereas the last one is not significant at the 5% level. We thus confirm that the above multicolinearity problem hardly arises in our data set.

The insignificant correlations imply that given a distance from the CBD, large lots and small lots are mixed in Osaka Metropolitan Area. This is in accord with casual observations in Japanese cities where wealthy households are located near the poor in many districts. To sum up, whereas the land price is decreasing in the access to the CBD, the lot size distribution (and hence, population density) does not exhibit such an empirical regularity in Osaka Metropolitan Area.

The second point is on the difference in land market constraints. According to the literature, quantity discounts ($\partial p/\partial s<0$) are observed in several American cities: the township of Ramapo (White, 1988), Champaign–Urbana (Colwell and Scheu, 1989), and nine cities (Holway and Burby, 1990). The opposite results to ours may be ascribed to several factors such as differences in population sizes, area sizes, city locations, and development histories. In particular, the average unit land price in Osaka Metropolitan Area is about 300 times as high as that in Ramapo while the average lot size in Ramapo is about 40 times as large as that in Osaka Metropolitan Area.

These comparisons would indicate that Osaka Metropolitan Area (as well as many big metropolitan areas in Japan) is so overpopulated that vacant land is scarcely left, implying that land assembly is a binding constraint. On the other hand, in Ramapo (and other American small cities), land is not so scarce, but there are other binding constraints such as large lot zoning, which restricts subdivision of land. Consequently, the land markets between Japan and the United States are not directly comparable. What we are dealing with in this paper is the scarce good.

4. Irreversibility in real property

Let us consider the economic implications of the above results in the land market contrasting with observations in commodity markets. Spence (1977) rightly states the following. "Quantity discounts tend to be undone by resale, where resale is possible. Quantity premiums are undone by repeat purchasing, where that activity is feasible and not too costly." In most of commodity markets, purchasing a commodity in large quantities and resaling it into multiple consumers is not easy since consumers need to coordinate. It is rather easy to purchase a commodity in small quantities repeatedly by the same consumer. It follows from these that quantity discounts are enforceable, but quantity premiums are not in many commodity markets.

In the land market, however, we have empirically shown that the reverse (quantity premium) is true. Unlike ordinary commodities, repeat purchase of contiguous lots is prohibitively difficult whereas resale by subdividing a large lot is easy in the land market because it is only due to the landowner's decision. Nonetheless, no lot will not be subdivided since the price of unit land is positively associated with lot size ($\partial p/\partial s>0$). On the other hand, landowners have an incentive to assemble their lots if possible because the unit land price becomes greater. Such intermediary business of land assembly is sometimes conducted by developers especially when land for office building is highly demanded in the business districts.

It is, however, rarely done in residential districts partly because benefits of a land price increase in residential districts are not so large as compared with those in business districts, and partly because in assembling lots developers have to mediate real property rights between landowners. For example, if one of the landowners is simply uninterested in an increase in the value of his real properties, then land assembly itself is not put into practice. Or, if a landowner may contrive to maximize his return by not selling his lot until all the other landowners bargain away their lots to a developer (Eckart, 1985). Then, the landowner can exploit the developer's super–normal profit from the project because in the negotiation he can gain an advantage over the developer who has already invested to purchase lots in the vicinity. Existence of such sunk costs in transaction is favorable to the landowner while unfavorable to the developer resulting in the impediment in land assembly.

We can therefore say that lot size is characterized by *irreversibility:* once it is subdivided and sold to different people, it is very difficult to be assembled as it was before because of the transaction costs. That is why quantity premiums are enforceable, but quantity discounts are not in the land market.

Let us next investigate the asset pricing of an apartment in a condominium. Here, the floor area of an apartment is used as a proxy for the lot size s, which is the quantity variable. Several empirical analyses in resent years demonstrate that there is a similarity between the apartment markets and the land markets. According to the analyses of condominium markets by Kato (1988), Arima (1992) and Nakamura (1992), quantity premiums prevail also in the apartment markets.

In building a condominium, a developer determines the floor area of each apartment so that the total asset price of the condominium is maximized. Since it is newly built, the developer freely determines the floor area of each apartment unit and its price without caring for any socio–political reasons inherent in the land markets mentioned above. Note, however, that once it is constructed, both assembly and subdivision of apartments are almost impossible. Unlike the land market, the irreversibility takes place in both directions in the apartment market. This implies that both quantity discounts and quantity premiums are enforceable as tools for nonlinear pricing in the apartment markets.

It is worth noting that the pricing of apartments is by no means cost–based as in ordinary commodities. If it were on a cost basis, then under increasing returns to scale in apartment construction the unit floor price would become higher for smaller apartment houses, which means quantity discounts. In reality, however, we have seen that quantity premiums are prevailing in those markets.

5. Theories of nonlinear pricing in a differentiated market

The developer's problem in Section 2 may be analyzed by the theory of nonlinear pricing developed by Spence (1977) and Mussa and Rosen (1978), where a monopolist offers differentiated products with a price–quality schedule exercising price discrimination via quantity discounts/premiums. Extending their analysis further, Maskin and Riley (1984) rigorously showed that quantity discounts are the optimal strategy in a monopolized market.

Following Tirole (1988), let us describe the nonlinear pricing model briefly. Consumers are heterogeneous in taste θ. A monopolist (developer) cannot observe θ, but knows its distribution, which is uniformly distributed over a nonnegative interval $[\theta_1, \theta_2]$. A consumer θ, purchasing a good (lot) with quantity (lot size) s and an outside numéraire good z, has an additively separable utility function given by[4]

$$U(s,z;\theta) = z + \theta u(s), \tag{3}$$

where $u'>0$ and $u''<0$ due to a decreasing marginal utility of s. The consumer's budget constraint is

$$y = z + P(s), \tag{4}$$

where y is the income, and $P(s)[=p(s)s]$ is the price of s. The first–order condition using (3) and (4) is

$$P'(s) = \theta u'(s). \tag{5}$$

The profit–maximizing monopolist offers a price–quantity schedule, which is derived from

$$\underset{P(s)}{maximize} \quad \pi = \int_{\theta_1}^{\theta_2} [P(s(\theta)) - cs(\theta)] \mathrm{d}\theta,$$

where c is the marginal cost of production. Solving this, we obtain

$$c = u'(s)(2\theta - \theta_2). \tag{6}$$

Substituting θ in (6) into (5) and differentiating yields

$$P''(s) = \theta_2 u''(s)/2 < 0.$$

We know from this and (5) that the monopolist's price schedule is increasing in quantity but at a decreasing rate, and hence the unit price is decreasing, implying the quantity discounts. This may be intuitively understood by the fact that the larger quantity is valued less owing to the assumption of decreasing marginal utility.

Alternatively, we may say that quantity discounts are a direct result of the first–degree or second–degree price discrimination. Under any downward demand function, the unit price is a decreasing function of quantity sold, which is equivalent to quantity discounts. Furthermore, economies of scale in retail and production technology is another conceivable reason for quantity discounts since we expect that lower costs of distribution and production are associated with a lower unit price.

Nevertheless, the analytical result of quantity discounts is invalidated by the empirical results in the real property markets, where quantity premiums are shown to exist. We should examine the model assumptions made by Maskin and Riley (1984) to see if some of them are against the actual situations in the real property markets.

Amongst the assumptions, it seems inappropriate to assume a decreasing marginal utility in space consumption in densely inhabited districts as in Japanese big cities. If $u(s)$ in (3) is increasing in s with an *increasing* rate, then the price–quantity schedule would become convex representing quantity premiums. Another inadequate assumption made above may be the monopolistic setting in the real property markets. Indeed, developers are usually local monopolists competing with their neighboring firms, and their property is not perfectly protected from an influence of other real property nearby. Real property is differentiated quantitatively in that different sizes mean different goods when a change in their sizes is prohibitively costly. (In a quality interpretation, different locations mean different goods due to environmental differences.) The differentiation is not horizontal, but vertical because real property with larger in size or better in location is more evaluated unanimously.

On the basis of these considerations, let us allow free entry of firms so that the market structure be oligopolistic in lieu of monopolistic, and relax the assumption of decreasing marginal utility. Following Anderson, de Palma and Thisse (1992, subsection 8.3.2), we would like to reformulate the above model. Now, the relative value of θ_2/θ_1 is given such that J firms (developers) are 'viable' in the market. consumers self–select among goods s_j (j=1,...,J). The utility function and the budget constraint are as (3) and (4) respectively except with subscript j added to s and P.

Firms play a noncooperative three–stage game. In the first stage, firms make an entry decision. In the second, they choose quantity s_j, and finally, they select price P_j. It should be noted that whereas the monopolist offers a price–quantity schedule in the above model, each oligopolist chooses a single quantity with a single price here.[5] Without loss of generality, let $s_j \leq s_{j+1}$ for all j=1,..,J–1. The market boundary $\hat{\theta}_j$ is then determined by the condition that a consumer $\hat{\theta}_j$ is indifferent between s_j and s_{j+1}. Namely,

$$y - P_j + \hat{\theta}_j u(s_j) = y - P_{j+1} + \hat{\theta}_j u(s_{j+1}) \qquad or$$

$$\hat{\theta}_j = \frac{P_{j+1}-P_j}{u(s_{j+1})-u(s_j)}.$$

Note that $s_j \neq s_{j+1}$ for all $j=1,..,J-1$ since firms avoid the Bertrand price competition yielding zero profit. Utilizing this expression, let us solve the third–stage game first. Each profit–maximizing firm optimizes its price as

$$\underset{P_j}{maximize}\ \pi_j = (P_j - cs_j)(\hat{\theta}_j - \hat{\theta}_{j-1}).$$

Computing the first–order conditions yields

$$\hat{\theta}_j - \hat{\theta}_{j-1} = \frac{P_j - cs_j}{u(s_{j+1})-u(s_j)} + \frac{P_j - cs_j}{u(s_j)-u(s_{j-1})} > 0 \quad for\ all\ \ j = 2,...,J-1.$$

From the definition of $\hat{\theta}_j$, we have

$$\frac{P_{j+1}-P_j}{u(s_{j+1})-u(s_j)} > \frac{P_j - P_{j-1}}{u(s_j)-u(s_{j-1})}\ for\ all\ j = 2,...,J-1, \tag{7}$$

given the choice of each s_j.

Suppose u is increasing and linear in s instead of concave. Then, since each side of (7) represents the slope of $P(s)$, and since it becomes steeper as s_j gets larger, it is evident that $P(s)$ is convex. This is also true in case that $u(s)$ is increasing and convex, i.e., increasing marginal utility in consumption of space. That is, the quality/quantity premiums take place in the oligopolistic differentiated product market, which does agree with the findings in the real property markets. Hence, we may conclude that the quantity premiums in the real property markets are attributed to the oligopolistic competition between developers selling lots and apartments which are vertically differentiated under the nondecreasing marginal utility in space consumption, and attributed to the irreversibility in assembling lots.

6. Concluding remarks

According to the theory of nonlinear pricing (Maskin and Riley, 1984), quantity discounts are shown to be optimal in a monopolized market. We tested the theory by using land market data in residential districts of Osaka Metropolitan Area in 1993. It was revealed that not the quantity discounts, but the quantity premiums are prevailing in the land market. We concluded that this is due to the irreversibility in changing lot size: once it is subdivided and sold to different people, it is prohibitively difficult to repurchase and assemble them as it was before because of existence of the transaction costs. Theoretically, the quantity premiums can be explained by the setting of a oligopolistic market with vertically differentiated products (Anderson, de Palma and Thisse, 1992) under nondecreasing marginal utility and/or nondecreasing returns to scale in production.

Returning to the original question raised in the beginning, we now got an answer to it partly. The result of quantity premiums means higher land values per unit for larger lot size. And so, developers and landowners tend to maximize their lot sizes by assembling contiguous lots if possible, and by sacrificing open space such as roads and parks if allowed. In case that the social benefits and costs are fully capitalized by land prices, such activities in a free market economy may be justified. However, being characterized as a (local) public good, the open space is likely to be underprovided due to free riders, which is one reason for the necessity of city planning by a public authority.

Another reason for city planning comes from the nature of irreversibility in changing lot size. Without any regulations like large lot zoning, some landowners may sell a lot by the piece just for personal convenience. As time goes on, lots are subdivided by piecemeal, which decreases the overall land price of the district, and prevents from efficient land use especially in the CBD where high rise building is highly demanded.

References

Alonso, William, 1964, Location and land use (Harvard University Press, Cambridge, Mass.).

Anderson, Simon P., André de Palma and Jacques–François Thisse, 1992, Discrete choice theory of product differentiation (MIT Press, Cambridge, Mass.).

Arima, Masahiro, 1993, Impact analysis of the large–scale redevelopment projects on condominium prices, in: Hiroyuki Yamada, ed., Fluctuations and diffusion of land prices in metropolitan areas, *Kaken* Report, 101–112. (in Japanese)

Asami, Yasushi, 1993, On the evaluation of residential lots: With a focus on their shape, Proceedings of the International Conference on Land Problem and Urban Policy held at Kyodai Kaikan, Kyoto, 292–326.

Champsaur Paul and Jean–Charles Rochet, 1990, Price competition and multiproduct firms, in: Paul Champsaur et al., eds., Essays in honor of Edmond Malinvaud, volume 1: Microeconomics, 162–187.

Colwell, Peter F. and Tim Scheu, 1989, Optimal lot size and configuration, Journal of Urban Economics 26, 90–109.

Eckart, Wolfgang, 1985, On the land assembly problem, Journal of Urban Economics 18, 364–378.

Edmonds, Radcliffe G, 1985, Some evidence on the intertemporal stability of hedonic price functions, Land Economics 61, 445–451.

Harrison, David and John F. Kain, 1974, Cumulative urban growth and urban density functions, Journal of Urban Economics 1, 61–98.

Holway, James M. and Raymond J. Burby, 1990, The effects of floodplain development controls on residential land values, Land Economics 66, 259–271.

Japan Land Agency, 1993, *Chika Kōji* in 1993 (Ministry of Finance, Tokyo).

Kato, Hisakazu, 1988, Impacts of housing loan policy on housing choice by consumers, Master's thesis, University of Tsukuba, Tsukuba. (in Japanese)

Maskin, Eric and John Riley, 1984, Monopoly with incomplete information, Rand Journal of Economics 15, 171–196.

Mussa, Michael and Sherwin Rosen, 1978, Monopoly and product quality, Journal of Economic Theory 18, 301–317.

Nakamura, Ryohei, 1993, Problems of simultaneity and identification in hedonic models, in: Hiroyuki Yamada, ed., Fluctuations and diffusion of land prices in metropolitan areas, *Kaken* Report, 83–100. (in Japanese)

Scotchmer, Suzanne, 1985, Hedonic prices and cost/benefit analysis, Journal of Economic Theory 37, 55–75.

Spence, Michael, 1997, Nonlinear prices and welfare", Journal of Public Economics 8, 1–18.

Suzaki, Kenji, 1991, Analysis of land price formation in Kanagawa prefecture, Master's thesis, University of Tsukuba, Tsukuba. (in Japanese)

Tirole, Jean, 1988, The Theory of industrial organization (MIT Press, Cambridge, Mass.).

White, James R., 1988, Large lot zoning and subdivision cost: A test, Journal of Urban Economics 23, 370–384.

Footnotes

[1] We settled on Table 2 after trying several functional forms and various kinds of explanatory variables such as area classification of zoning regulations, ratio of frontage to depth, width of a front road, levels of infrastructure, and so on.

[2] This finding is also supported by Edmonds (1985) and Suzaki (1991) although their data and the forms of equation (1) are somewhat different.

[3] Scotchmer (1985) argues that the lot size is endogenously determined by the distance and so on in the context of hedonic theory.

[4] While s expresses the level of quantity here, it can be considered as the level of quality throughout the paper.

[5] Such a 'bunching' of consumers may be justified by Champsaur and Rochet (1990), who proved that each duopolist produces a unique quality (quantity) without restriction on quality (quantity) ranges.

	Land price per area p [1000 yen/m^2]	Area size s [m^2]	Distance to the nearest station x_2 [m]	Time to the CBD x_3 [minutes]
Average	245	180	1320	27.7
Standard deviation	71.6	90.9	1090	10.2

Table 1 Summary statistics for the variables

Independent variables	Keihan & Katamachi Lines	Hanwa & Nankai Lines	Kintetsu Osaka & Nara Lines	All Six Lines
Area size	0.000676 (4.37)	0.000249 (2.37)	0.000436 (2.94)	0.000422 (4.62)
Distance to the nearest station	-0.000079 (7.38)	-0.000085 (6.41)	-0.000152 (14.0)	-0.000139 (18.8)
Time to the CBD	-0.0128 (9.78)	-0.0226 (28.0)	-0.0317 (19.6)	-0.0243 (29.7)
Line dummy 1 (1=Keihan Line)	0.224 (7.53)			0.0934 (3.72)
Line dummy 2 (1=Katamachi Line)				-0.187 (3.71)
Line dummy 3 (1=Hanwa Line)		-0.0846 (4.43)		-0.234 (9.25)
Line dummy 4 (1=Nankai Line)				-0.160 (5.94)
Line dummy 5 (1=Osaka Line)			-0.114 (3.64)	-0.164 (6.28)
Constant	5.74 (54.4)	6.09 (55.1)	6.52 (35.9)	6.31 (39.4)
R^2 for log p	0.650	0.849	0.866	0.812
R^2 for p	0.627	0.817	0.728	0.704
Number of oservations	112	167	165	444

Note: Dependent variable is log p.
Absolute values of the t statistics are in parentheses.

Table 2 Regression analysis of equation (4)