Spatial Characteristics of Land Prices in Bangkok

Nitinant Wisaweisuan*

With the initiation of subcentres and construction of many new transport channels in Bangkok, it is questionable whether or not the spatial structure of the city has transformed significantly and, in turn, pronounced any change in land price patterns. This paper addresses these issues by examining spatial behaviour of land prices during the 1990s. Estimation of land price gradients reveals always significantly negative values, which were flattening over the period of study and varied from sector to sector. While access has continued to play a crucial role, quality of infrastructure and public utilities, and the specific location of the land plot in different sectors proved to be statistically significant factors contributing to differences in land prices. Last, that the emerging subcentres are not effective enough to outweigh the primacy of the CBD in reforming declining patterns of land prices allows us to adopt a monocentric assumption, with a consideration of sectoral structure, when pursuing further studies relating to urban areas of the Bangkok metropolis.

Keywords: Bangkok, land prices, monocentric model

1. Introduction

Bangkok plays the major role in Thailand's development in many aspects. Not only is it acting as a centre of income generation, but the city also provides superior quality services necessary for residents' welfare, such as leisure, education and health. The substantial size of economy, accounting for 37% of the total GDP of the country (NESDB, 1998), and the availability of employment opportunities has attracted an influx of

* Faculty of Economics, Thammasat University

population into the metropolis.[1]

This has made urbanisation in Bangkok to occur very rapidly and, over time, extended the geographical frontier farther and farther from the city centre. If an increase in population continues, we could anticipate an increase in demand for residences as well as for other goods. This would undoubtedly lead the city to develop even more densely. However, due to variation in locational advantages, it is not surprising that the degree of urban growth is uneven. A general observation of Bangkok's development suggests that not only the market, but also planning, forces have taken part in crystallising the urban area to exhibit certain distinctive characteristics, as follows:

First, it is apparent that areas on the periphery have experienced faster rates of growth, in response to reduced availability of vacant land in the inner area. This was particularly accommodated by newly constructed transportation routes linking the city centre and outlying areas. The provision of road access was asserted as one of the most effective measures of increasing land prices and hence inducing greater supply of land for development (Dowall, 1989). This was later empirically proved by estimation of land price gradients for Bangkok Metropolitan Region (BMR).[2] Dowall (1992) revealed that during 1988-90, land plots that were located on the main road were valued higher than those located farther away by 165-221 per cent.

---

[1] The census in 2000 indicates that Bangkok's population accounts for 10.4% of the total population in Thailand. During 1960-2000, the number of *registered* residents grew from 2 million to nearly 6 million, and overall density has increased from 1,365 to 3,613 persons per square kilometre (NSO, 2000). However, the actual population in Bangkok was estimated to be always much higher than the registered amount. For example, OCMRT (1996) projected the actual population based on the urban and transport database management to be approximately 10 million in 1998.

[2] BMR at that time included Bangkok and three surrounding provinces; namely, Nonthaburi, Samutprakarn and Pathumthani. But from the time being, the definition of BMR has been extended to include the other two provinces, which are Samutsakhon and Nakhonpathom.

Secondly, there has been an imbalanced degree of urbanisation and development amongst different sectors of the city. Specifically, the eastern area of the Chao Phraya River was much more developed than the western part, particularly toward the northern and the eastern corridors (BMA, 1996a). This has taken place because of several encouraging and discouraging factors. Examples include the availability of transportation routes that facilitated development toward the east (Kaothien and Webster, 1995); the construction of the Eastern Seaboard since the early 1980s that had attracted a number of job opportunities (Pinto, 1994); and the unattractiveness of the western area itself, where a number of industrial sites had developed (Greenberg, 1994).

Urbanisation directing to the western sector was nonetheless accelerated since the mid-1980s. According to Chomchan (1990), the earlier obstacle was removed considerably after the construction of bridges over the river and several new roads within the area were completed. A survey conducted for the Urban Planning Project (BMA, 1996b) revealed that the greatest urbanised land areas during 1990-95 were located in the western suburbs, which increased by 161%, compared with only 15% in the inner city, 66% in the eastern inner fringe, and 92% in the eastern suburbs.

Thirdly, while the improvement of the transportation network has facilitated development to be continuing into the outer suburbs, the Bangkok Metropolitan Authority (BMA) officially initiated a number of subcentres surrounding Bangkok metropolis along the outer ring road. These were to decentralise growth and alleviate both intra- and inter-city congestion problems. However, in the late 1980s and even in the early 1990s, these subcentres have been unsuccessful either in terms of attracting new jobs or encouraging decentralisation. Punpuing (1993) regards this phenomenon as owing to the insufficient quality infrastructure that made a number of employers reluctant to make a move.

Together with other economic and social changes that Bangkok has experienced, they suggest that the city undergone a certain degree of spatial transformation. Especially, investment of infrastructure and creation of subcentres can, to a certain extent, reformulate the overall urban structure, and, over time, the city that was empirically concluded as a monocentric type in 1980s by Dowall (1992) could transmute into the Harris and Ullman's (1945) multiple-nuclei city. If this happens, the previously found negative land price gradients could exhibit other patterns; then further analysis relating to urban areas of Bangkok based simply on the monocentric model would be inappropriate. Whether the spatial structure of land prices in Bangkok has changed significantly over the last decade has not yet been fully verified.

The paper attempts to address this issue by employing land prices as a basic tool. It particularly examines their spatial pattern during the 1990s, both in descriptive and quantitative manner. In addition, as one may postulate a relationship between land prices, land use and overall urban structure, we further utilise what we learn about the spatial pattern of land prices to draw implications on patterns of urban structure as well as transportation characteristics. Previous studies exclusively on land prices in cities worldwide are abundant while those relating land prices to urban structure are relatively scarce. It is therefore an aim of this paper to fill this gap.

2. Spatial Distribution of Land Prices and Land Use Pattern

A number of land price studies have followed the simple, but fundamental, access-space trade-off idea, as developed by Alonso (1964) and Muth (1969). The essence of the *trade-off* relationship is that land prices are required to decline with distance to compensate for higher transportation costs, as an individual moves away from the central business district (CBD). This enables the individual to acquire a larger piece of land in compensation for less convenient access to the CBD.

As for other economic theories, this however holds true only within a restricted framework that assumes the following. First, a city is assumed to be monocentric, whereby an urban area is characterised as a one dimensional, flat and featureless plain, and assumed to be congestion-free. The location of workplaces is given and is assumed to be in the CBD only. Secondly, transportation is assumed to be available in a uniform pattern; that is, the CBD is accessible from all directions with a cost proportional to the distance and the number of travel trips. Besides, it assumes market competition to ensure that necessary information relevant for an individual's decision be available so as to allow demand and supply forces to work interactively in the extent to attain equilibrium. Last, preferences are assumed to be identical among all individuals.

2.1 Derivation of Trade-off Relationship

Given the above assumptions, a rational individual would maximise utility function (u), which is defined in the simplest form as

$$u = u\,(z,\, q) \tag{1}$$

subject to a budget constraint, which is given as

$$y = z + p(x)q + T(x,y) \tag{2}$$[3]

where y = income;
z = quantity of the composite good;
q = quantity of land for a particular use;
$p(x)$ = price of land at distance x kilometres from the city centre;
$T(x,y)$ = commuting costs incurred when travelling x kilometres from where the land is located to the city centre; and

[3] Note that the price of the composite good is normalised to unity.

x = distance from the location of land to the city centre.

The necessary conditions for equilibrium can be attained via the Lagrangian Multiplier as follows. Note that the subscripts refer to the partial derivatives.

$$L = U(q, z) + \lambda \{y - z - p(x)q - T(x,y)\} \quad (3)$$

$$\frac{\partial L}{\partial q} = U_q - \lambda p(x) = 0 \quad (4a)$$

$$\frac{\partial L}{\partial z} = U_z - \lambda = 0 \quad (4b)$$

$$\frac{\partial L}{\partial x} = -\lambda(qp_x + T_x) = 0 \quad (4c)$$

$$\frac{\partial L}{\partial \lambda} = y - z - p(x)q - T(x,y) = 0 \quad (4d)$$

By making use of equation (4), we can constitute the consumption equilibrium as well as the trade-off concept, and make inferences about the relationship between the spatial pattern of land prices, land use and urban structure. That is, we re-arrange equation (4c) and obtain the location equilibrium defined as

$$-qp_x = T_x \quad (5a)$$

The left-hand side of equation (5a) is the reduction in expenditures necessary to purchase a given quantity of land as a result of moving a unit distance away from the CBD. The right-hand side term indicates the increase in transport costs incurred by such a move. The equality of the two terms suggests that the location equilibrium require the 'net' saving from a move either toward or away from the CBD to be zero. As a consequence, individuals cannot increase their real incomes by any relocation if they were at equilibrium.

By rearranging equation (5a), we alternatively get

$$P_x = -\frac{1}{q} T_x \qquad (5b)$$

Due to an increase in transport costs with distance ($T_x > 0$) and the always positive quantity of land ($q > 0$), equation (5b) therefore can be satisfied if, and only if, $p_x < 0$. In other words, this condition says that land prices decline with distance from the CBD.[4] According to the demand theory, the quantity demanded for land will rise with distance, in response to the reduction in its price. This statement clearly expresses the *trade-off* relationship between access and space; that is, at a location nearer to the CBD, the greater access is offset by higher land prices and the consequent reduction in space acquired.

2.2 Land Price-Distance Function, Land Use and Urban Structure

In neoclassical economics, market mechanism allocates pieces of land to users on the basis of the bidding process. In other words, the person who gives maximum bidding will always win the competition and be able to get the piece of land for his or her intended use.[5] Based on the Alonso's (1964) framework, different perceptions upon accessibility can be reflected by different degrees of steepness of bid-price curves. The higher

---

[4] The trade-off relationship still holds, even if we modify the utility function into some other more complicated forms. For example, Muth (1969) took into account the number of daily trips and allowed transport cost to vary with number of trips, in addition to distance to the CBD. White (1988) included time costs in addition to monetary cost when calculating transport costs. The survey on existing modifications to the simple Alonso model produces the consensus that negative price gradients will remain, as long as the assumptions on identical preference and monocentric city are maintained. But once the preference for location, such as neighbourhood and environment, is taken into account, other patterns of land price gradients could result (Straszheim, 1987).

[5] In reality, landowners could consider other incentives than purely profits and, therefore, supply the land to the non-highest bidder (Needham, 1982, Evans, 1983, Neutze, 1985, Walters, 1983 and Wiltshaw, 1985).

the value of access is, the more desirable a land plot and the willingness to bid will be. Then a steeper bid-rent curve will result.

Via competition among a variety of bidders, this lends us an understanding of distribution of economic activities as well as ultimate urban formation, as follows: Assuming an economy with only five activities in the city; namely '*a*', '*b*', '*c*', '*d*', and '*e*', each of which has its corresponding price-distance relationship as depicted as a, b, c, d and e in Figure 1. Economic activity '*a*', such as business, placing the greatest valuation on areas in and nearer the city centre, will always win the bidding in any distance from the CBD within the '*a*' ring. Using the same principle, the location within the '*b*' ring will be occupied by '*b*' activity. This works the same for '*c*', '*d*' and '*e*'. As a consequence, a resulting arrangement of optimal locations and spatial structure of the city, as portrayed in Figure 1, is analogous to the Burgess' (1925) concentric ring model.[6]

2.3 Convexity of Land Price-Distance Function

It is not necessary and, in fact, very unlikely, for the land price-distance function to be linear. As illustrated previously in Figure 1, the resulting rent function is an envelope of all winning bid price curves, which exhibits varying slopes with distance. From the locational equilibrium given in equation (5b) above, we examine the spatial characteristics of price gradients by taking a second-derivative with respect to distance and get

$$P_{xx} = -\frac{1}{q}\left[T_{xx} - \frac{T_x q_x}{q}\right] \tag{6}$$

Provided that the land price falls with distance as predicted by

[6] Burgess (1925) postulated a model of urban structure in forms of concentric ring. Starting from the most centre ring toward suburbs, economic activities are distributed in the following order: the CBD, the transition area, the low-income workers, the middle-income residence and the commuters' zones.

the *trade-off* relationship, the quantity of land acquisition increases with distance ($q_x > 0$). In a congestion-free situation, T_{xx} is less than or equal to zero, mathematically, the equation (6) produces a positive sign of p_{xx}. This suggests that, under some circumstances as restricted by the above assumptions, the price-distance function is downward sloping and convex to the origin.

The convexity of the curve may be explained simply on the basis of the capital-labour substitution in production function. Provided that the rate of substitution is not fixed, when prices of land in an inner area are high, it is more economical to substitute more capital for land and develop a piece of land more densely. Intensive use of land will drive land price per unit even higher. Businesses that especially prefer economies of agglomeration available in an inner area, in addition to relatively greater accessibility, would be willing to place even higher bids in acquiring land. On the other hand, as land costs at outer areas are lower, development can take place easily at a less intense degree. These make a decline in land prices not proportional to distance. In turn, it is reasonable for a number of previous studies to undertake analysis by relying on a non-linear specification form.

2.4 Past Evidence

Estimation of land price gradients has been undertaken extensively for several cities. When negative and significant gradients are established, we may explain the location pattern of economic activities in the city on the basis of accessibility to the city centre. Alternatively, we may conclude that the observed rents purely designate 'location' rent, and not other aspects such as 'externality' rent.[7] In this respect, the formation of urban structure may be predicted if circumstance of access changes.

---

[7] Difference between 'location' and 'externality' rent can be found in Richardson (1977). With the presence of desirable characteristics that produce positive externalities, such as good environment, at any farther distance, the would-be lower land prices could become higher.

The majority of studies, with modification where appropriate, have been successful in producing negative price gradients (see examples in Table 1). Studies are, however, relatively more abundant in relation to developed cities, whose structures are now reasonably well-understood (such as Abelson, 1997 for Sydney; Rose, 1992 for cities in Japan; and Soderberg and Janssen, 2001 for Stockholm, among many others). In some cases, there may even be too much of a concentration on one particular city. For example, McDonald (1979), McDonald (1984), McDonald (1987), McDonald (1989), McDonald and McMillen (1990) and McDonald and Prather (1994) are all studies of the Chicago metropolitan area.

On the other hand, evidence for developing cities remains relatively scarce, especially for the Asian countries, where lately there has been a strong degree of economic growth and urbanisation. Recent examples are Dowall and Leaf (1991) and Sun and Basuki (2001) for Jakarta, Amitabh (1997) for cities in India, Dowall and Treffeisen (1991) for Bogota, Columbia and Asabere (1981) for Kumasi, Ghana.

Although negative gradients were successfully revealed, the estimated values obtained from these different studies vary, which is due to different urbanisation processes and city sizes involved. The existence of this difference to a certain extent makes comparison and generalisation technically problematic; yet they exhibit certain characteristics. For example, Rose (1992) conducted studies of this kind for a number of Japanese cities, including Tokyo, Osaka and Nagoya. It was revealed that, at a given point in time, the absolute gradients become lower systematically, when the geographical boundary of the sample is bigger.

Apart from negative gradients, a majority of studies reveal a pattern of flattening price gradients over time, which implies lower prices of land in areas adjacent to the city centre and higher land prices in suburbs. Then one may conclude that a suburbanisation is in process. An exception can be found in a study by Sun and Basuki (2001) undertaken

for Jakarta in 1996-97. Specifically, they found steeper and significant gradients, and concluded that this reflected more difficulty in reaching the city centre.

An analysis was also made possible even if there was a lack of data. Dowall and Leaf (1991) developed their own technique, which was later applied to several developing cities and became a guideline for land market assessment (Dowall, 1993). A further study was pursued using a parallel method to examine the spatial pattern of overall residential land prices such as in Jakarta, Karachi and Bangkok in the late 1980s (Dowall, 1992). It was found that Jakarta's land price gradients were much steeper than those found in the other two cities. While the gradients in Bangkok were only about two-thirds the level of those in Jakarta, the gradient in Karachi was less than half of Jakarta's (see Table 1). These differences were interpreted as reflecting the differences in transportation accessibility and the patterns of population density found in those cities.

Apart from accessibility, literature has revealed other types of explanatory variables that may explain levels of land prices in different areas. One group is the availability of utilities and infrastructure. Sun and Basuki (2001), for example, included a dummy variable to represent the risk of flooding at the location of the land plot. They found a negative sign of coefficients, implying that an area with a flood risk was likely to have a lower land value than an area without such a risk.

The literature as mentioned above has produced findings that are consistent with the urban location theory - as revealed by negative land price gradients. However, as a city develops, the importance of distance in relation to other emerging factors in determining land values may diminish. Accordingly, empirical evidence obtained from purely the land price-distance function could produce generally lower explanatory power, and/or either positive or a statistically insignificantly negative price gradient. Distortion in negative gradients is therefore possible, and can be explained by a number of factors.

Past evidence pronounces that possible failure to obtain negative gradients is owing to the fact that cities are neither monocentric nor as simple as the trade-off assumes. With a fully-developed subcentre, one may observe an additional peak of land prices around that subcentre. As a consequence, a consideration of subcentres is crucial, especially in a case of a more developed and complicated city. This is because, in the reality of a multi-centre city, a premise located further away from the city centre does not have to be less attractive if it is closer to other centres of employment and commercial activities. Shieh (1987) demonstrated theoretically that it is not necessary to have a continuously decreasing bid rent function when we move away from the CBD and that the building of new shopping centres between the existing two commercial centres would cause an increase in bid rent at that location.

Such a distortion in the land price pattern could also be generated by intervention of government when imposing certain types of constraints on development in particular areas. For example, land use controls may prevent the bidding process from operating efficiently. In this case, the spatial pattern of land prices does not conform to the trade-off model. As a consequence, instead of having systematic and smooth negative price gradients, there may be discontinuities in the price-distance function to modifying the slope of the gradients in the neighbouring areas to the controlled zone (Evans, 1983 and 1999).

These mean that the contradictory results could represent a biased estimate that is a result of the omission of other important variables but, nonetheless, that can be removed by appropriately including these variables to the model. To date, there are a number of attempts to refine and elaborate the traditional trade-off model in an extent to remove such a bias, and successful in turning a positive gradient into the negative one (see excellent summary in, for example, Arnott, 1987 and Cheshire and Mills, 1999). These factors comprise, for example, externalities (Waddell *et al.*, 1993); decentralised urban structure (McDonald and McMillen, 1990)

and advanced and better quality transportation (White, 1994). In most cases, they have been successful in showing that the basic idea of access-space *trade-off* relationship is acceptable and applicable, at least in its simplest form and in certain situations.

3. Analytical Framework

Review of both theory and past evidence suggests that variables explaining land prices be classified broadly into three groups: accessibility to the CBD and other centres; physical structure of the land plot itself; and the characteristics of location and surrounding areas. In other words,

$$P(x) = f\ (access,\ physical\ structure,\ location\ characteristics) \qquad (7)$$

In the analysis of spatial pattern of land prices in Bangkok, we hypothesise that accessibility plays a crucial role, which can be evidenced by negative gradients. Besides, we postulate that subcentre and sub-urbanisation has taken effect in modifying land prices to a certain extent. Testing these requires significant coefficients of distance to subcentre and flattening patterns of land price gradients, respectively. Locational advantages, such as quality of infrastructure, are also thought to be crucial in raising land prices, though their impacts are expected to differ spatially. An empirical test of the land price model will also help us quantify the degree as to which each factor contributes to differences in land prices.

3.1 Data

Prior to an estimation of land price gradients, we examine behaviour of land prices in general. There are mainly two types of land prices in Thailand; namely, government-appraised and market-assessed values. Appraised prices, collected by the Department of Lands, are published every four years for the purpose of taxation and other policy administration. They are used, for example, as a standard to calculate compensation for

land expropriation required for public construction. And market prices are available from the Agency for Real Estate Affairs (AREA).[8]

During the early 1990s, when property prices were high, appraised values were at very low levels, compared with market prices, and there were delays in their adjustments to the market situation. On average, appraised prices were generally only about 20-30% of market prices (Likasitthananon, 1996). We then utilised data from the AREA to examine levels of market and appraised prices at the plot level in the late 1990s. A consideration of data of 101 land plots from AREA reveals a narrower gap in 1997. On average, the market-to-appraised price ratio was 1.24, indicating that the appraised prices were about 81% of the market prices (see Table 2).

The smaller gap between market and appraised prices in 1997 could be attributable to either one or all of the following reasons. First, the revision of the appraisal method by the Department of Lands in 1996 that tried to catch up to the up-to-date market situation resulted in a higher scale of appraised prices throughout the country. At the same time, the property collapse in 1997 has drastically pulled down market prices, as witnessed by a decline in real market prices by approximately 12.6% annually during 1994-97.

What interests us now is the spatial pattern of land prices. Though appraised and market values differ in level, we believe they possess similar spatial patterns. Considering their discrepancies in different locations, we found that the ratio of market to government prices increases slightly from 1.23 to 1.24 and then to 1.35 in the inner, the middle and the outer rings, respectively, before markedly falling to 1.03 in the suburbs (see

[8] AREA is a private company that supplies relevant information on land and housing markets to the related agencies, such as the National Housing Authority (NHA) and the Department of Lands.

Table 2). This could, to some extent, reflect difference in perception upon potential of development in a particular location between private and public sectors. Since the procedure of measuring appraised prices is based on a more fundamental set of factors, the rather more conservative method may fail to properly reflect information on the prospects of development and expected future returns. Therefore, we choose market prices in this study.

3.2 Estimation Procedure

As indicated earlier, a land price function can exhibit any forms, not only a linear one. As the exact functional form of the land price equation is subject to controversy, we consider this an empirical matter. A correct specification is necessary especially if we wish to make use of the estimates to quantify an impact of transport costs and other factors on land prices at various locations, as did Coulson (1991). The most popular general method used to test nonlinearity of a variable is the Box-Cox transformation (Box and Cox, 1964), in which a variable y is transformed to $(y^{\lambda}-1)/\lambda$. The selection of λ is based on the maximum likelihood method. In particular, the dependent variable can take one of the following forms:

$$y^{(\lambda)}=\begin{cases} y & \text{if } \lambda = 1 \\ \ell ny & \text{if } \lambda = 0 \\ 1-\frac{1}{y} & \text{if } \lambda = -1 \end{cases} \quad (8)$$

Deflated by using the Bangkok consumer price index (1994=100) to eliminate inflation, we employ the Box-Cox transformation to check an appropriate functional form of land prices in 1994 and 1997. The result as shown in Table 3 indicates that a natural log specification for dependent variables cannot be rejected at the 1% level of significance.

Therefore, we estimate land price functions using the following forms:

Without sectors:

$$\ln P_i(x) = \ln V(0) + \lambda_1 x_{CBD} + \lambda_2 x_{SUB} + \sum_{j=1}^{J} \delta_j d_j + \varepsilon_i \quad (9)$$

With sectors:

$$\ln P_i(x) = \ln V(0) + \lambda_1 x_{CBD} + \lambda_2 x_{SUB} + \sum_{k=1}^{K-1} \alpha_k s_k + \sum_{k=1}^{K-1} \beta_k s_k x + \sum_{j=1}^{J} \sum_{k=1}^{K} \delta_k d_j s_k \varepsilon_i \quad (10)$$

where $P_i(x)$ is land price of an ith plot located at distance x_{CBD} kilometres from the city centre and x_{SUB} kilometres from the nearest subcentre; s_k is a set of variables representing sectors; d_j is a set of dummy variables representing locational characteristics. $\hat{\lambda}_1$ is interpreted as land price gradient; $\hat{\delta}_k$ measures an impact of locational advantage in the kth sector on land prices and $\hat{\beta}_k$ shows difference in price gradients in the kth sector.

Different specifications based on different underlying city structures may account for different results of estimates. Dowall and Treffeisen (1991), for example, estimated land price gradients for Colombia in 1973 and 1985, using two functions. Price gradients obtained from a multi-centre model were steeper, and having greater level of significance, than those obtained from a monocentric model. Overall results from the former one also indicated more accurately an impact of access *per se*. In case of Bangkok, the specification that recognises an importance of subcentre is preferred, for it has experienced rapid urbanisation and development toward a multi-centre city.

It is worth noting that we can be confident of using economic tools based on neoclassical theories in this study. This is because the Bangkok land market has been considered as an example of a market-based system, with only a limited range of effective government planning and intervention (Dowall, 1989 and Pamuk and Dowall, 1998). The market mechanism is therefore generally allowed to operate freely and interpreta-

tion of results is consistent with the economic theory.

3.3 Variables

To identify the pattern of land prices with distance, we adopt a monocentric assumption and reveal the influence of access on land prices by employing the distance to the CBD *(DISTCBD)* as an explanatory variable. The distance was measured as the shortest road distance from land plots to the CBD - defined as the Bangkok Bank Headquarters on Silom Road.[9] Though this measurement does not reflect exactly the condition of accessibility to the CBD, it can be argued to sufficiently reflect the situation of commuting to city centre.[10] More importantly, it makes comparison over a period of time feasible.

To test whether or not subcentres are successful in raising land prices in surrounding areas, we add a variable that represents the road distance from land plots to the nearest subcentre *(DISTSUB)*. If being significant, it may be implied that Bangkok has been transformed into a multiple-centre city.

Change in locational advantages as cities expand is one among many factors that determine levels of land prices (Dunkerley, 1983). Basically, locational advantages take place when the condition of an area is improved by means of transportation and quality of infrastructure. We

---

[9] It is worth noting that different results may be obtained if relying on different centres (Kahimbaara, 1986). Although Bangkok has no readily defined CBD, this study chooses Silom as the CBD due to its distinctive characteristics. Examples are a high percentage of economic activity and a small amount of vacant land (Kaothien and Webster, 1995) and a steady and high employment concentration (Pinto, 1994).

[10] In reality, other factors than distance, such as quality of transportation modes and distribution of available activities at destination, may influence condition of access. As a consequence, if one wishes to use land rents to more accurately provide insights on transportation and locations of major economic activity, construction of an index of accessibility may be beneficial. A variety of accessibility measurements can be found in, for example, Hanson and Schwab (1987) and Handy and Niemeier (1997).

test its importance by adding a dummy variable, *INFRA* to represent condition of infrastructure available at the land plot. As evaluated by the AREA, it is assessed on the basis of road conditions, the quality of communication, drainage system and electricity. *INFRA* takes on a value of 1 when a land plot is equipped with good or very good infrastructure, and 0 if otherwise.

We further hypothesise that the city is divided into different sectors (as postulated by Hurd's axial model of urban structure), each of which has different levels of land prices. However, 'sector' is a rather ambiguous term. In Bangkok, we define sector by using the major transportation routes available from the CBD and the Chao Phraya River.

We first divide the overall area into *EAST* and *WEST* and test whether or not the Chao Phraya River is significant in producing varying land prices by adding an explanatory variable - *RIVER*. It takes on the value of 1 if the land is located on the eastern bank of the River and 0 if otherwise.

Alternatively, we separate Bangkok into sectors based on major transportation routes available from the CBD. That is, we further divide the western bank of the River into the northwestern (*NW*) and the southwestern (*SW*) sectors by the Thonburi-Paktor Road leading to the southwest direction. The eastern bank of the River is divided into the northeastern (*NE*) and the southeastern (*SE*) sectors by the Ramkamhang-Sukhapiban Road. We further re-classify some of the northeastern subsamples that are located on the west of the Vibhavadi-Rangsit Highway into the northwestern so as to capture the influence of the Highway on land prices. Ultimately, Bangkok is segmented into four sectors; namely, northwest (*NW*), northeast (*NE*), southeast (*SE*) and southwest (*SW*) areas, as illustrated in Figure 2.

4. Estimation Results

We begin our analysis based purely on the monocentric framework by including only *DISTCBD* in land price function. This is to examine the sole impact of access to the city centre. Results in both 1994 and 1997 revealed negative gradients; however, diagnosis tests suggest existence of basic regression problems, including misspecification form and omitted variables. We were successful in correcting the specification errors when adding square of *DISTCBD (DIST2)*, while the problem of omitted variables remains (Table 4 column (a)). Although all estimates are significant, it is doubtful if they are unbiased. To correct this, we re-estimate them using variables as specified by equation (10). Doing so produces problem-free results. Discussion henceforward is therefore based on this specification.

As shown in Table 4 columns (b) and (c), the quantitative tests of land price gradients produce satisfactory results. Generally, all types of explanatory variables explain variations of land prices during the 1990s as highly as 90%. Price gradients are always negative and significant. They also exhibit a pattern of flattening price gradients over time, suggesting that suburbanisation has been undergoing in Bangkok.

Findings of estimation with sectors clearly suggest that there exist an importance of the locational differences on land prices. On average, market prices of land plots in the eastern area of the Chao Phraya River were higher by approximately 116% in 1994 and this difference declined in 1997 to be 87%. However, findings based on a more detailed classification using transportation routes are more satisfactory. They revealed differences in average land prices by sector, with the absolute values of gradients in the following descending order: southwestern, northeastern, northwestern and southeastern sectors. In statistical terms, however, only the southeastern area has revealed, although weakly, significant price gradient, compared with the southwestern sector. This pattern repeats for 1997. These, all in all, simply indicate a variety of perceptions toward accessibility existing in different areas.

Now we examine whether land price gradients differ in disaggregated concentric rings. We divide observations into three groups by distance from the CBD. They include the inner, the middle and the outer rings, which refer to land plots that are located within 10, between 11-20 and more than 20 kilometres from the CBD. We observe that values of gradients vary with distance, with steepest gradients in an innermost ring (Table 5). This implies varying conditions of transport from sector to sector, with the most costly transport in the inner ring.

In addition, we observe flatter gradients over time in all the rings, although this is not statistically significant in the middle ring. These, according to equation 5 (b) imply relatively lower transportation costs. However, transportation costs, in reality, are comprised of both monetary and non-monetary costs. It is relatively simple to measure the monetary costs, as they are the direct expenses incurred equally by individuals who travel within the same distance using the same mode at the same time. The non-monetary costs, on the other hand, are rather subjective values, and can vary by individual due to their own judgements of valuation of travelling time. Moreover, a variety of modes of transportation choices and the quality of transportation networks that link points of activity in the city can largely account for different travel speeds and result in different levels of non-monetary costs to commuters. Therefore, the reduction in total transport cost implied by estimated market price gradients can mirror either the reduction in money costs or the greater speed of travel, which altogether implies improved accessibility to the city centre.

We observe an interesting feature from estimation of land prices in different rings. As shown in Table 5, there is a consistent increase in the values of adjusted r-squared at outer rings in both periods of study. In detail, access and quality of infrastructure explain land prices in the inner ring by approximately 50-53%, while their explanatory power increased to 57-59% and 74-75% in middle and outer rings respectively. We can imply that accessibility as well as infrastructure has been perceived

as more important at outer areas. On the contrary, lands at the inner area are well-equipped with a good quality of basic infrastructure and having easy access to the city centre. Then levels of land prices are determined by some other important factors than purely access and public utilities.

Regarding this issue, we reveal that influence of infrastructure on land prices is not even in all concentric rings. It has no significant impact on prices of land in the inner ring (see Table 5). Greatest impact is on the middle ring. Here we may predict that over time quality of infrastructure would be more important in further outlying areas, especially when development spreads out. This indicates room for government in providing good condition of infrastructure, not only road access but also other necessary infrastructure, such as communication, as incentives to promote subcentres and decentralise growth. More importantly, not only is the sufficient amount, but consistent and continuous provision of infrastructure is also required for sustainable development.

We now turn to examine an importance of emerging subcentres. While commuting becomes more relieved, it implies that access to the CBD can be easier even though one locates a premise farther from the CBD but closer to a subcentre. Estimation results, as shown in Table 4, reveal that the strength of distance to the nearest subcentre that was significant in 1994 became empirically weaker in 1997. This could be attributed to the economic situation when the year 1997 saw the economic crisis and property market collapse. The condition of economy at that time could have threatened companies, for which it could have been more economical to relocate their branches formerly situated at periphery back to the headquarters established in the city centre. Drop in demand for lands at outlying areas was a major cause of the drop in land prices there.

In a more detailed spatial level, it is noticeable that we were not successful in obtaining significant gradients of land prices in the middle ring, while we obtain significant coefficients of *DISTSUB*, with a decline in

absolute values from 0.0957 in 1994 to 0.0711 in 1997 (Table 5). Relatively stronger importance of the nearest subcentres than the CBD *per se* on land prices leads us to hypothesise that additional peak(s) of land prices could be observable in the middle ring, and that over time the peak would move outward.

Higher land prices in the middle ring could be attributed to higher demand for residences within the area. Since the early 1990s, a number of Bangkok residents had acquired a second home, mostly in the form of a condominium, located nearer to the city centre at an affordable cost, so as to save commuting expenses. The majority of newly built condominiums, both for sale and for rent, in the innermost area are however luxurious and targetted mainly to high-income households, while cheaper but moderate standard housing are located farther. Therefore, for both affordable commuting expenses and housing costs, a second home in middle ring may be the second-best choice for a majority of households already having dwellings in Bangkok suburbs. Moreover, as there have been new locations for offices constructed in middle ring, such as the Siam Commercial Bank Park Plaza, office complexes on Sukhumvit Road and others, they would very likely encourage greater demand for residences in the location nearby, and bring about higher land prices in general. Over time, we anticipate to observe more additional peaks of land prices in the areas farther from the CBD but closer to a subcentre.

Another interesting observation is that the formerly significant *DISTSUB* in outer ring in 1994 turned to be insignificant in 1997. This could confirm what we asserted earlier that the phenomenon was partly a result of the economic crisis. Then, we may depict *hypothetical* land price function as Figure 3 below.

Besides, we can observe distinction in different sectors. In addition to different gradients, we found that the quality of infrastructure plays a considerable role in generating higher market prices, and that their

impacts vary by sector. As implied by Table 4 column (b), the premium of infrastructure on land prices is greater in the western bank of the Chao Phraya River. That is, with superior quality infrastructure, the coefficients of *EASTINFRA* and *WESTINFRA* indicate that land prices would be higher by approximately 33-36%% and 131-139% in the eastern and southern banks respectively. This indicates an existence of extensive disparity of quality of land in the west.

Considering results from Table 4 column (c), when classifying sectors by transportation route, the southwestern sector saw the greatest influence of quality infrastructure on land prices. Specifically, better quality of infrastructure significantly brought about market prices to be higher by approximately 203% in 1994 and 166% in 1997. The degrees of importance of this factor vary in the following descending order: northwestern, southeastern and northeastern sectors. Better quality of infrastructure produced higher market prices, respectively, by 91% both in 1994 and 1997, 92% in 1994 and 82% in 1997, and 27% in 1997 and 30% in 1997. This is not surprising because the northeastern sector has long been established; this makes differentials in impact of infrastructure on land prices relatively least.

Another interesting question is whether the change in the spatial pattern of land prices is significant over the period of study. We perform the chow test by calculating F-statistic as follows:

$$F = \frac{[RSS_{all} - (RSS_1 + RSS_2)]/k}{(RSS_1 + RSS_2)/(n_1 + n_2 - 2k)} \qquad (11)$$

where RSS_{all} = residual sum of squares obtained from regressing combined samples;

RSS_1 = residual sum of squares obtained from regressing the first subsample;

RSS_2 = residual sum of squares obtained from regressing the second subsample;

n_1 and n_2 = number of observations in the first and second subsample respectively; and

k = number of regressors including constant.

Results shown at the bottom row of Table 4 indicate that the *overall* structure of spatial distribution of land prices in Bangkok has changed significantly. However, this is insufficient to identify explicitly whether or not the flattening pattern of gradients between 1994-97 was significant. We test this query by making use of a dummy variable technique (Gujarati, 1995). That is, we regress all samples at once by adding a dummy variable, called *YEAR*, which takes on value of 1 if an observation is for 1997 and 0, if otherwise. In addition, we add *YEARDIST*, which is a multiplicative variable between *YEAR* and *DISTCBD*. Its estimated coefficient represents change in price gradients during the period of study.

We found that generally the decline in price gradients was significant at 5% level of confidence. But in more details, it was only the southwestern and southeastern areas that have significant flattening price gradients (Table 6). These imply that suburbanisation has successfully established a change in the pattern of land prices during 1994-97 only in these two sectors. We also found significant estimates of *YEAR* in every sector, which indicates that the highly significant drop in market price took place in the crisis year (1997) compared with 1994. The reduction in average prices was greatest in the southeastern sector, followed by northeastern, southeastern, and northwestern sectors, respectively.

5. Conclusion

This paper examines the spatial distribution of land prices in Bangkok. Estimation of land price gradients during 1994-97 reveals always statistically significant and negative gradients. The addition of other variables to capture the influence of sector and infrastructure improves the goodness of fit, while not affecting the fundamental result of a negative gradient.

With a variable representing an importance of subcentres, land price gradients remain negative and strongly significant. These findings do support what the theory predicts, and adds to the collection of empirical regularities found elsewhere (Ingram, 1998). More importantly, we can imply that while emerging subcentres are, to a certain extent, significant in raising land prices in surrounding areas, they cannot outweigh the primacy of the CBD in the extent to reform the overall pattern of the city. Yet, it is not a foregone conclusion that the pattern will persist, as the findings relate to only the 1990s. Over time, as the economy recovers from the crisis, making the newly initiated subcentres more mature and attracting employment, the suburbanisation of job location could lead to an increase in land prices and a comparable change in population densities at greater distances from the CBD.

This paper also confirms that the Bangkok land market is differentiated and can be segmented into sectors by transportation routes. In addition to access, difference in quality of infrastructure and transportation routes in different areas produces different impacts on land prices as well as the extent of suburbanisation. Therefore, at least for the time being, a monocentric assumption, with appropriate modification (particularly with recognition of sectors), is acceptable for further study relating to urban areas of Bangkok.

References

Abelson, P. (1997) Housing and land prices in Sydney from 1931 to 1989. *Urban Studies*, vol. 34, pp. 1381-1400.

Alonso, W. (1964) *Location and land use: toward a general theory of land rent.* Cambridge MA, Harvard University Press.

Amitabh (1997) *Urban land markets and land price changes: a study in the third world context.* Aldershot, Ashgate.

AREA. (1998) *Bangkok land prices 1994-2000.* Bangkok, Agency for Real Estate Affairs.

Arnott, R. (1987) Economic theory and housing. In: Edwin S. Mills (ed) *Handbook of Regional and Urban Economics*, Amsterdam, North-Holland, vol. 2, pp. 959-988.

Asabere, P. (1981) The price of land in a chiefdom: empirical evidence on a traditional African city, Kumasai. *Journal of Regional Science*, pp. 529-539.

BMA. (1996a) *Bangkok plan*. Bangkok, Bangkok Metropolitan Authority.

_____. (1996b) *Structuring suburban growth in the BMA*. Activity Report, Bangkok, EC/ BMA Urban Planning Project.

Box, G. E. P. and D. R. Cox. (1964) An analysis of transformation. *Journal of the Royal Statistical Society*, Series B, vol. 26, pp. 211-243.

Burgess, E. W. (1925) The growth of the city. In: R. E. Park (ed) *The City*, Chicago, University of Chicago Press.

Cheshire, P. and E. S. Mills (eds) (1999) *Handbook of Regional and Urban Economics*. vol. 3: Applied Urban Economics, North-Holland, Elsevier Science.

Chomchan, S. (1990) *Land use development in Bangkok and major cities: directions and problems*. Bangkok, Thailand Development Research Institute.

Coulson, N. E. (1991) Really useful tests of the monocentric model. *Land Economics*, vol. 67, pp. 299-307.

Dowall, D. E. (1989) Bangkok: a profile of an efficiently performing housing market. *Urban Studies*, vol. 26, pp. 327-339.

_____. (1992) A second look at the Bangkok land and housing market. *Urban Studies*, vol. 29, pp. 25-37.

_____. (1993) The land market assessment: a new tool for urban management. *Urban Management Programme Policy Paper No.4*, Washington D.C., World Bank.

Dowall, D. E. and M. Leaf (1991) The price of land for housing in Jakarta. *Urban Studies*, vol.28, pp. 707-722.

Dowall, D. E. and P. A. Treffeisen (1991) Spatial transformation in cities of the developing world: multinucleation and land-capital substitution in Bogota, Colombia. *Regional Science and Urban Economics*, vol. 21, pp. 201-224.

Dunkerley, H. B. (1983) Introduction and overview. In: H. B. Dunkerley and assistance of C.M.E. Whitehead (eds) *Urban Land Policy: Issues and Opportunities*, Washington D.C., The World Bank, pp. 3-39.

Evans, A. W. (1983) The determination of the price of land. *Urban Studies*, vol. 20, pp. 119-129.

_____. (1999) The land market and government intervention. In: P. Cheshire and E.S. Mills (eds) *Handbook of Regional and Urban Economics*, vol.3: Applied Urban Economics, North-Holland, Elsevier Science, pp. 1637-1669.

Greenberg, C. (1994) *Region based urbanisation in Bangkok's extended periphery*. Ph.D. Thesis, University of British Columbia.

Gujarati, D. N. (1995) *Basic Econometrics*. 3rd edition. Singapore, McGraw-Hill.

Handy, S. L. and D. A. Niemeier (1997) Measuring accessibility: an exploration of issues and alternatives. *Environment and Planning A*, vol. 29, pp. 1175-1194.

Hanson, S. and M. Schwab (1987) Accessibility and intraurban travel. *Environment and Planning A*, vol. 19, pp. 735-748.

Harris, C. D. and E. L. Ullman (1945) The nature of cities. *The Annals of the American Academy of Political and Social Science*, vol. 242, pp. 7-17.

Ingram, G. K. (1998) Patterns of metropolitan development: what have we learned? *Urban Studies*, vol. 35, pp. 1019-1035.

Kahimbaara, J. A. (1986) The population density gradient and the spatial structure of a third world city: Nairobi, a case study. *Urban Studies*, vol. 23, pp. 307-322.

Kaothien, U. and D. Webster (1995a) *Bangkok: regional form, economic restructuring, and changing social expectations. Paper presented at the International Symposium on Regional Cities.* Cambridge, Massachusetts, USA, 16-19 September 1995.

_____. (1995b) *The proposed development frame for the core area of the Bangkok metropolitan region during the eighth plan period (1997-2001). Paper presented at the UNCRD International Seminar on Human Settlements Policies 95 "Settlements Problem in Metropolitan Core Areas."* Tokyo, Japan, 9-10 March 1995.

Likasitthananon, T. (1996) *A study of land expropriation in Bangkok: a case study of an expressway project*. M.A. Thesis, Thammasat University.

McDonald, J. F. (1979) Economic analysis of an urban housing market. In: Edwin S. Mills (ed) *Studies in Urban Economics*, New York, Academic Press.

_____. (1984) Changing patterns of land use in a decentralising metropolis. *Papers of the Regional Science Association*, vol. 54, pp. 59-70.

_____. (1987) The identification of urban employment subcentres. *Journal of Urban Economics*, vol. 21, pp. 242-258.

_____. (1989) Econometric studies of urban population density: a survey. *Journal of Urban Economics*, vol. 26, pp. 361-385.

McDonald, J. F. and D. P. McMillen (1990) Employment subcentres and land values in a polycentric urban area: the case of Chicago. *Environment and Planning A*, vol. 22, pp. 1561-1574.

McDonald, J. F. and P. J. Prather (1994) Suburban employment centres: the case of Chicago. *Urban Studies*, vol. 31, pp. 201-218.

Muth, R. F. (1969) *Cities and housing: the spatial pattern of urban residential land use.* Chicago and London, University of Chicago Press.

Needham, B. (1981) A neo-classical supply-based approach to land prices. *Urban Studies*, vol. 18, pp.91-104.

Neutze, M. (1987) The supply of land for a particular use. *Urban Studies*, vol. 24, pp. 379-388.

OCMRT (1996) *Coordination for mass transit construction project.* Final Report, Bangkok, Office of the Commission for the Management of Road Traffic.

Pamuk, A. and D. E. Dowall (1998) The price of land for housing in Trinidad: the role of regulatory constraints and implications for affordability. *Urban Studies*, vol. 35, pp. 285-299.

Pinto, S. (1994) *Locational patterns of office activity in Bangkok: an economic analysis.* M.A. Thesis, Thammasat University.

Punpuing, S. (1993) Correlates of commuting patterns: a case study of Bangkok, Thailand. *Urban Studies*, vol. 30, pp. 527-546.

Richardson, H. W. (1977) On the possibility of positive rent gradients. *Journal of Urban Economics*, vol. 4, pp. 60-68.

Rose, L. A. (1992) Land values and housing rents in urban Japan. *Journal of Urban Economics*, vol. 31, pp. 230-251.

Shieh, Y. N. (1987) A model of residential location in a two-dimension, multi-centre city. *Papers of the Regional Science Association*, vol. 63, pp. 71-79.

Soderberg, B. and C. Janssen (2001) Estimating distance gradients for apartment properties. *Urban Studies*, vol. 38, pp. 61-79.

Straszheim, M. R. (1987) The theory of urban residential location. In: E. S. Mills (ed) *Handbook of Regional and Urban Economics*, North-Holland, Elsevier Science, pp. 717-757.

Sun, S. H. and A. Basuki (2001) The spatial pattern of land values in Jakarta. *Urban Studies*,

vol. 38, pp. 1841-1857.

Waddell, P. A. *et al.* (1992) Residential property values in a multinodal urban area: new evidence on the implicit price of location. *Journal of Real Estate Finance and Economics*, vol. 7, pp. 117-141.

Walters, A. A. (1983) The value of land. In: H. B. Dunkerley and assistance of C.M.E. Whitehead (eds) *Urban Land Policy: Issues and Opportunities*, Washington D.C., The World Bank, pp. 40-62.

White, M. J. (1988) Location choice and commuting behaviour in cities with decentralised employment. *Journal of Urban Economics*, vol. 24, pp. 129-152.

White, M. J. (1994) Housing and the journey to work in US Cities. In: Y. Noguchi and J.M. Poterba (eds) *Housing Markets in the United States and Japan*, Chicago and London,The University of Chicago Press, pp.133-159.

Wiltshaw, D. G. (1985) The supply of land. *Urban Studies*, vol. 22, pp. 49-56.

Table 1. Selected Empirical Evidence on Land Price Gradients

Author(s)	City	Year	Gradients
Developed Cities			
Abelson (1997)	Sydney	1931-1968	Negative & significant
McDonald (1979)	Chicago	1960	-1.264*
	(residential land)	1970	-1.121*
	Chicago (non-residential	1960	-1.215*
	land)	1970	-0.255
McDonald and	Chicago	1928	-0.160*
McMillen (1990)	Chicago (Single-family	1961	-0.060*
	residence)	1971	-0.076*
		1981	-0.036*
Rose (1992)	Tokyo, Osaka, Nagoya, Japan	1985	Negative & significant
Son and Kim (1998)	Korean cities		-0.027 (Seoul) to -0.290 (Kwang-ju)
Soderberg and Janssen (2001)	Stockholm, Sweden	1992-94	-0.112*
Developing Cities			
Asabere (1981)	Kumasi, Ghana	1970-79	-0.037
Dowall (1992)	BMR (comprising BKK,	1988	-0.057*
	Nonthaburi, Pathumthani,	1989	-0.056*
	and Samut Prakarn)	1990	-0.054*
	Jakarta +		Range of -0.169 to -0.181
	Karachi +		Range of -0.07 to -0.08
Sun and Basuki	Jakarta, Indonesia		
(2001)	Linear specification using stepwise regression		
	Minimum values	1996	-23.45*
		1997	-24.74*
	Maximum values	1996	-205.15*
		1997	-241.72*
	Average values	1996	-118.74*
		1997	-133.32*
Dowall and Leaf	Jakarta, Indonesia	1987	-0.181*
(1991)		1988	-0.174*
		1989	-0.169*
Dowall and	Bogota, Colombia		
Treffeisen (1991)	*Using a multicentre model*	1973	-0.108*
		1985	-0.089*
	Using a stepwise	1973	-0.087*
	procedure	1985	-0.076*

Notes: * significance at 1% level of confidence

+ reported in Dowall (1992)

Table 2. Ratio of Market to Appraised Land Prices, 1997

Distance from CBD	Market Prices	Appraised Prices	Market-to-Appraised Prices
Inner ring: 0-10 km	212,848	173,323	1.23
Middle ring: 10-20 km	87,147	70,282	1.24
Outer ring: 20-30 km	28,379	21,100	1.35
Suburbs: >30 km	11,813	11,419	1.03
Overall	**108,434**	**87,392**	**1.24**

Note: prices are in Baht per square wah.[11]
Source: Data from AREA (1998)

Table 3. Chi-Square Values as Obtained from Box-Cox Transformation on Real Market Prices

Test if	1994		1997	
	Business	Residence	Business	Residence
$\lambda = -1$	14.93	36.95	6.38	47.58
$\lambda = 0$	0.01	1.29	0.42	2.94
$\lambda = 1$	14.72	14.55	15.07	9.70
Number of Iterations	**2**	**3**	**3**	**3**

[11] Wah is a measurement of land size in Thailand. A square wah is equivalent to 4 square metres.

Table 4. Estimation Results of Land Price Gradients

	a) No Sectors		b) Sectors classified by Chao Phraya River		c) Sectors classified by major transport routes	
	1994	**1997**	**1994**	**1997**	**1994**	**1997**
Constant	12.4261	12.0059	11.8098	11.4485	11.6456	11.2690
	*(74.49)**	*(77.71)**	*(47.19)**	*(46.73)**	*(31.96)**	*(30.82)**
DISTCBD	-0.1078	-0.1041	-0.1006	-0.0967	-0.1112	-0.1025
	*(6.29)**	*(7.43)**	*(6.33)**	*(6.41)**	*(5.32)**	*(4.93)**
DIST2	0.0008	0.0008				
	*(2.04)***	*(2.73)**				
DISTSUB	-0.0879	-0.0551	-0.0482	-0.0220	-0.0495	-0.0264
	*(4.05)**	*(3.03)**	*(2.36)***	*(1.25)*	*(2.84)**	*(1.68)****
INFRA	0.5249	0.5024				
	*(4.81)**	*(4.97)**				
RIVER			0.7696	0.6345		
			*(2.66)**	*(2.26)***		
RIVERDIST			0.0134	0.0166		
			(0.87)	*(1.14)*		
EASTINFRA			0.2826	0.3069		
			*(2.49)***	*(2.86)**		
WESTINFRA			0.8694	0.8385		
			*(5.55)**	*(5.45)**		
NWINFRA					0.6464	0.6525
					*(3.92)**	*(3.95)**
SWINFRA					1.0180	0.9786
					*(3.92)**	*(3.76)**
SEINFRA					0.6532	0.5991
					*(3.32)**	*(3.54)**
NEINFRA					0.2380	0.2590
					*(2.04)***	*(2.21)***
NW					0.3636	0.3409
					(0.86)	*(0.81)*
NWDIST					0.0160	0.0121
					(0.72)	*(0.54)*
SE					0.3838	0.2037
					(0.85)	*(0.47)*
SEDIST					0.0385	0.0395
					*(1.78)****	*(1.86)****
NE					1.3285	1.2192
					*(3.37)**	*(3.08)**
NEDIST					0.0087	0.0087
					(0.42)	*(0.41)*
Observations	95	101	95	101	95	101
F-stat	136.25	148.40	134.71	136.68	93.84	90.69
Adj R2	0.8520	0.8550	0.8951	0.8906	0.9222	0.9150
Chow Test	5.36*		5.06*		3.32*	

Note: 1. Figures in parentheses represent absolute t-statistics of the respective estimates.

2. *** significant at 10%; ** significant at 5%; * significant at 1%

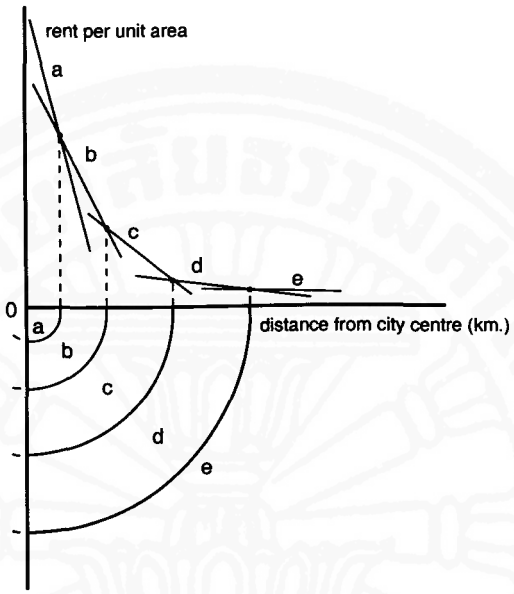
Table 5. Estimation Results of Market Price Gradients by Concentric Zone

	1994			1997		
	0-10 km	**11-20 km**	**> 20 km**	**0-10 km**	**11-20 km**	**> 20 km**
Constant	13.0922	11.4362	11.4370	12.6898	11.1685	10.9872
	*(61.60)**	*(21.29)**	*(30.50)**	*(62.26)**	*(23.59)**	*(32.34)**
DISTCBD	-0.1212	-0.0539	-0.0558	-0.1175	-0.0505	-0.0515
	*(4.83)**	*(1.45)*	*(5.28)**	*(4.89)**	*(1.64)*	*(5.35)**
DISTSUB	-0.0525	-0.0957	-0.0680	-0.0860	-0.0711	-0.0307
	(0.78)	*(2.17)***	*(2.80)**	*(1.33)*	*(1.90)****	*(1.42)*
INFRA	-0.1861	0.9922	0.7311	-0.1476	0.8450	0.7691
	(1.08)	*(4.74)**	*(4.90)**	*(0.89)*	*(4.72)**	*(4.94)**
Observations	33	33	29	33	34	34
Adj R2	0.4964	0.5943	0.7546	0.5335	0.5740	0.7401
F-stat	11.51	16.63	29.69	13.20	15.82	32.32

Table 6. Testing Significance of Change in Price Gradients over Time

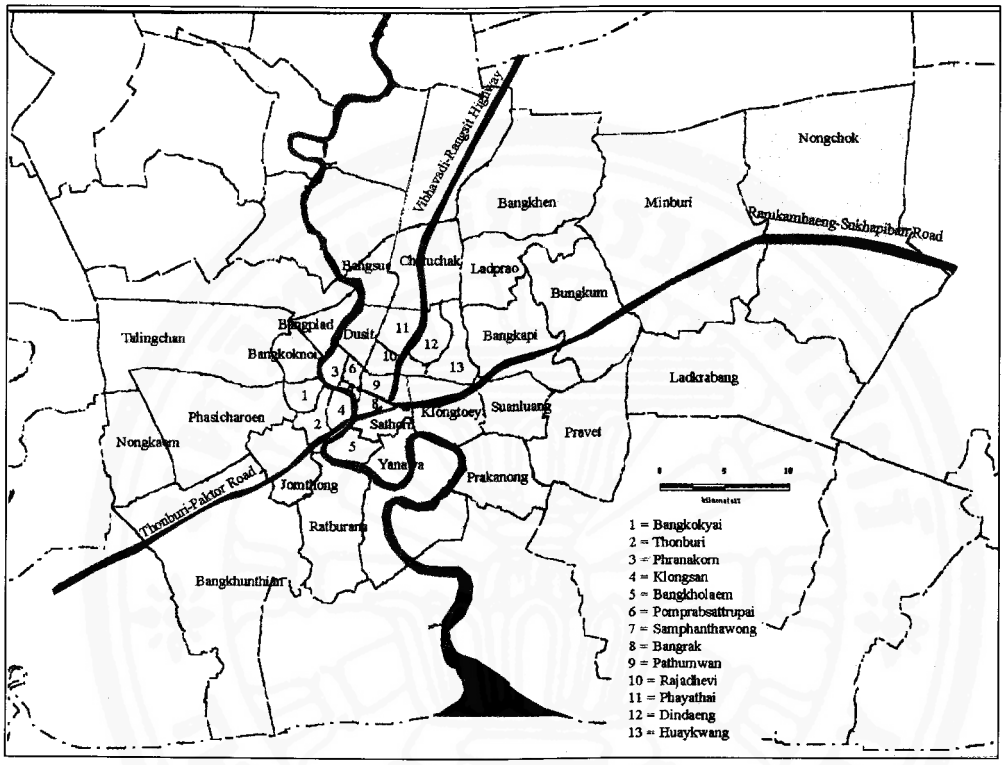
Sector	**Northeast**	**Southeast**	**Southwest**	**Northwest**	**All**
Constant	12.9730	12.0614	11.7786	12.0148	12.2301
	*(94.26)**	*(57.95)**	*(91.99)**	*(70.16)**	*(107.10)**
DISTCBD	-0.1017	-0.0750	-0.1753	-0.0977	-0.0782
	*(16.93)**	*(10.61)**	*(15.57)**	*(7.96)**	*(15.38)**
YEAR	-0.4470	-0.6111	-0.4429	-0.4200	-0.4587
	*(2.92)**	*(2.97)**	*(4.07)**	*(2.21)***	*(3.89)**
YEARDIST	0.0110	0.0144	0.0193	0.0133	0.0129
	(1.53)	*(1.74)****	*(2.08)***	*(1.02)*	*(2.16)***
DISTSUB	-0.0543	-0.0363	0.1227	-0.0428	-0.0802
	*(2.79)**	*(1.64)*	*(5.55)**	*(1.97)****	*(5.75)**
INFRA	0.2424	0.6168	1.0163	0.6487	0.4983
	*(2.73)**	*(4.78)**	*(12.39)**	*(5.89)**	*(6.56)**
Observations	77	41	28	50	196
Adj R2	0.9236	0.9287	0.9832	0.8768	0.8492
F-stat	184.63	105.27	316.43	70.75	220.66

Figure 1. Price-Distance Curve and Formation of Spatial Structure



Note: a, b, c, d and e denote types of economic activities or groups of people, each of which has different perceptions upon valuation of accessibility and resulting willingness to bid for land at a particular location.

Figure 2. Area of Study and Classification of Sectors



Note: Classification of districts is as of 1997.

Figure 3. Hypothetical Land Prices-Distance Functions in Bangkok