Residential land value modelling

------- Case study of Hankou, China-------

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by

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Abstract

Land valuation is the process of assessing the characteristics of a given piece of land. The process may be described as a carefully considered estimate of the worth of landed property based on experience and judgment. However, the objective of land valuation is to determine the land value; a term generally prefaced by some description such as market value or benefit value. In the land valuation, it is a common understanding that the value and potential of a property are fundamentally determined by its location. This emphasizes the significance of spatial factors in decision making of land valuation. A geographical information system (GIS) is undoubtedly useful in this decision making. A sufficient estimation can be done by analyzing a certain amount of land characteristics in an objective way. In order to make adequate value estimation for a land, there are many tangible and intangible land valuation factors that should be taken into account during the valuation process. In this paper, Hankou town in Wuhan, China is selected as the study area. This thesis, the residential land value model has been constructed using the sale comparison approach and multiple regression analysis. In this method rather than dealing with the real-market prices, the qualitative and quantitative characteristics of individual land properties have been examined. To determine the value of a land, some land valuation criteria are selected and formulated so that property values are assigned by the numerical parameters rather than real-market values. These parameters are derived from a combination of the selected land valuation factors which can be spatially analyzed by using GIS. Land value can then determined as a single unit figure which represents all factors affecting the land as compared to others. Comparisons between the benchmark price and the predict land value, it has proved that the model of residential land value is appropriate in Hankou urban area. As a result, a visual land valuation model created which will be readily understood by individuals unfamiliar with mass appraisal procedures as well as appraisal professionals.

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1. Introduction

1.1. Background

Urban land can be classified into different types of land uses e.g. residential, commercial and industrial etc. The encountered problems regarding urban land involve the high costs to develop land (install infrastructure) and the competing land uses such built-up versus agricultural, residential versus commercial and conflicting urban land uses such residential and adjacent industrial areas. Unlike other commodities, land is not consumed over fixed or expected periods of time. The allocation and use of land resources are affected by the physical and biological, economic and institutional factors (Barlowe 1978). In the developed world, high levels of living standards and income, technological and communication outgrowth, economic, political and demographic stability derive the need for land. In the less developed world, the need for land is affected by exacerbated urban and population growth, the limited resources for the provision of housing and other services, the imperfect operation of real estate markets, low levels of income of citizen and planning techniques for cities future growth. State control over urban land covers aspects of land-use, zoning, building regulations, taxation, eminent domain, finance, conservation and others. However, centralized governmental policies and control in most less developed countries create ineffective land delivery system and distortions in normal land market behaviour.

Urban land has economic, environmental, historic, and social values. The value of developed urban land is an of the most important cost aspect of the value of a dwelling. Normal conditions and factors that influence residential land values in the free market include location, proximity and accessibility, development cost, productivity, shape and size of the parcels and the demand for land (which is derived from the demand for the output). The demand for housing is influenced by natural population growth, migration, increasing urbanization, changes in income status, stage of economic growth and change in land productivity (Barlowe 1978). Increasing housing demand will lead to increased pressure on land, developed urban land is getting a scarce resource which causes increasing competition between developers for land in specific locations with favourable shapes and sizes. This process, eventually, will lead to increased land prices depending on different land use.

Land values, and especially urban land value patterns, are complex due to its intrinsic spatial pattern. The analysis of the spatial pattern of residential land values is of vital importance for urban development and land management. The theories on land values of the early and mid 1950s reveal that the urban spatial pattern has significant influence on land value patterns (Nzau 2003). Alonso (1964), Muth (1969) and others differentiate land prices in a bid-rent function that explains land prices in relation to transportation costs and distance from the CBD and subcenters. Land prices tend to decrease with increasing distance from the centres. The consumer equilibrium occurs when the increasingly unit cost of transportation equals the decreasingly unit cost of land and housing. Decreasing commuting and transportation costs, and advances in communication technology decrease the need for face-to-face contact among office workers, allowing some firms to move to the subcenters and allowing others to decouple their operations into CBD activities and suburban activities. Workers are willing to pay more for housing and land near employment centres (everything else being equal), so the land-rent function has several peaks, one near the CBD and one near each sub-centre. Sullivan (1993) suggested that the monocentric, core-dominated city has been gradually replaced with the multicentric, suburbanized city. The land-rent surface has local peaks at the city centre and the subcentres within the city, and forms a ridge centred on the beltway.

The development of suburban subcentres is driven by the suburbanization and clustering of retailers and office firms. Retailers moved to the suburbs to be closer to their customers and clustered in sub-centres to exploit shopping externalities and have easier accessibility by private cars (e.g. parking space). Manufacturing and office firms move to the suburbs to be closer to their work forces and clustered to exploit agglomerative economies. Nevertheless, this process keeps land prices at peaks in city centres and leaves land prices in suburban sub-centres at lower values. Hence, the supply of urban land in this case becomes more elastic.

When land is supplied with a strong influence of the Government, political choice factors that include compulsory purchase, subsidies, quality of services, land use patterns, amount of supplied land, and disposals of land at minimum prices for some uses affect land prices (Needham 1992). Municipalities supply land for marketable uses at maximum prices, using the concept of residual land value, in other words, the land is assumed to be improved to its highest and best use. All expenses of operation and the return attributable to the other agents of production are deducted, and the net income imputed to the land is capitalized to derive an estimate of the land and improvements and deducting the costs of the improvements and any entrepreneurial profit, the remainder is the residual lands value. However, it is depending upon the type of development (land use, building intensity, etc.). Hin Li (1997) argued that land prices in Shanghai, where land is supplied publicly, depend on the production-cost value using the private treaty mechanism. However, market land prices, which are set by local authorities in Shanghai, proved to be higher than residual land prices, if land were supplied in a free market and transparent system. However, both market economic factors and political choice factors affect land prices in Shanghai which witnesses a stage of economics in transition from socialization to privatization.

As Jones and Ward (1994) argued, most of the above models of land allocation are bid-rent models (figure 2-1). They are unable to explain the variations of land values in specific locations. It is still unclear what influences are on the behaviour of spatial land value patterns, especially of the specific characteristics of cities in developing countries. Ever since Alonso developed his bid-rent theory, many studies (Ingram G. K and Carroll A 1981; Dowall and Leaf 1991) have been carried out on spatial land value pattern and factors determining them, although they have found that these patterns of declining land values hold true for cities around the world regardless of their stage of development (Dowall and Leaf 1991). A lot of the emphasis of the recent researches has been placed on the accessibilities and locational externalities. For example, Issam et al. (2001) states that availability of park space, retail jobs are estimated to positively impact residential land values, and as a result, the land rents track homeowners' assessments of accessibility. In Geoghegan's (2002) analysis, it is observed that open spaces increase nearby residential land values. In the study of Nzau (2003), the percentage land value changes near the CBD are higher than those near only one sub-centre but lower than those near the other two sub-centres. From all these studies, it has become clear that there is a need for better understanding of the main influence factors of residential land value in developing cities.

1.2. Problem statement

With China opening its land market to investors, the government has moved to tackle the lack of comparison data for establishing market prices by formulating a system that allows local authorities to estimate average land prices on the basis of land grades for different uses. Called the Benchmark Price (BMP), the idea is to provide a market reference point of average land prices in each Chinese city so local authorities can have a set of guidelines when leasing land use rights to investors. Land development has occurred through private approaches to the local authorities using a system of implied pricing implemented with varying degrees of rigour, and honesty. Public auctions of leases on sites cover China large cities after year 2000.

This marks a further step towards the rationalization of China's land use mechanism, with the leases containing highly restrictive development covenants being sold at auction, at full residual value. Whilst this system has obvious immediate revenue attractions - it is effectively a 100 per cent betterment levy on the planning uplift from current use value. For example, from 2001 to 2003, Wuhan showed rapid land revenue increase. The Tax on Real Estates, Tax on Use of Land and tax on increase the land value are increase 23%, 2%, and 707% respectively.

In Wuhan, its first open land auction took place in March. 2001. The land price of this property project for residential land use was sold at the price of 68 million RMB Yuan (US$8.3 million) of 8.3 hectares, almost doubling the opening bid of 36 million RMB Yuan (US$4.4 million). Meanwhile, the income from the transaction of the urban land-use right has become important revenue for both central and local governments of China. Since the urban land-use rights can be owned by the users for relatively long periods, it means that for a specific period, the number of the land transaction is limited. That requires the municipalities have sufficient knowledge of the real land value and well manage the urban land resource to achieve sound profits from the land-use right transactions. Thus, the benchmark price has been adopted in land administration.

However, after the start of the land reform Wuhan city has experienced a drastic change both in the urban size and the urban land use pattern over the last 10 years. Like most other large cities in the southeast of China, the economic success and development potential makes the city still keeps fast developing with rapidly changing land-use patterns. The distribution of land values is seen as important by the land administrators in Wuhan city. And the land market in Wuhan city has changed rapidly due to large development projects at present, it is thus necessary to provide accurate information concerning these land values in order to better steer and regulate the urban land market and plan the demand for land, and enable integrated development towards desirable spatial patterns of land uses. The Benchmark Price (BMP) update should be a regular fundamental task, necessary for appreciation of land values. But there is still no systematic comparison and analysis of how the land value is influenced by the urban land-use pattern, especially at the level of the micro locational characteristics of land parcels on land values. Actually, the fast expansion of the city and changing urban land-use pattern has the profound influence on both the general circumstance on the macro/city scale and the micro circumstance for every corner of the city. Urban land value can be directly influenced by its location and a lot of other physical factors (e.g. land qualities). The urban spatial land-use pattern has great importance in deciding the residential land value. In this research the influence of the micro circumstance caused by the surrounding land uses of the samples will be studied, and a proposed model of residential land value will be constructed based on these theories. With the application of the new technologies such as geographic information systems (GIS), which can handle and process large amounts of spatial data, it is possible to associate and process large number of the land value data and locational data, and take the analysis with multi-original data.

1.3. Research objectives

1.3.1. Main objective

To analyze the spatial land value patterns of the residential land use in Hankou town, and develop a land valuation model to estimate land values for residential land use in Hankou town in order to update regularly the Benchmark Price.

1.3.2. Sub-objectives

1. To determine the spatial variation of urban residential land value in the current land market policy.
2. To develop a model of land valuation for residential land use
3. To evaluate the suitability of the model for Hankou town

1.4. Research questions

The research questions related to the above objectives are:

Sub-objective1:

- What are the spatial patterns of land values in Hankou town?
- Which spatial factors influence the value of residential land use in Hankou town?
- What is the relationship between the residential land values and influence factors?
- Which appropriate procedure in SPSS is applied to identify the variables of significant correlation with residential land values?
- What is the strength of these different factors influence the residential land value?

Sub-objective2:

- What is the structure of a residential land valuation model appropriate for Hankou town?
- (How to design an approach to model the residential land values appropriate for Hankou town?)

Sub-objective3:

- How to estimate the model?
- How well does the model agree with actual land values in Hankou town?

1.5. Research framework

The above questions are explored with the aid of a diagram (figure1-1), which portrays the research framework of this study, so the case will concentrate on the literature study which concerns with land valuation and model development of land valuation. It will also review the land market in China, including the valuation aspect. The research will also deal with the development of a land valuation model and designing a proposed valuation system:

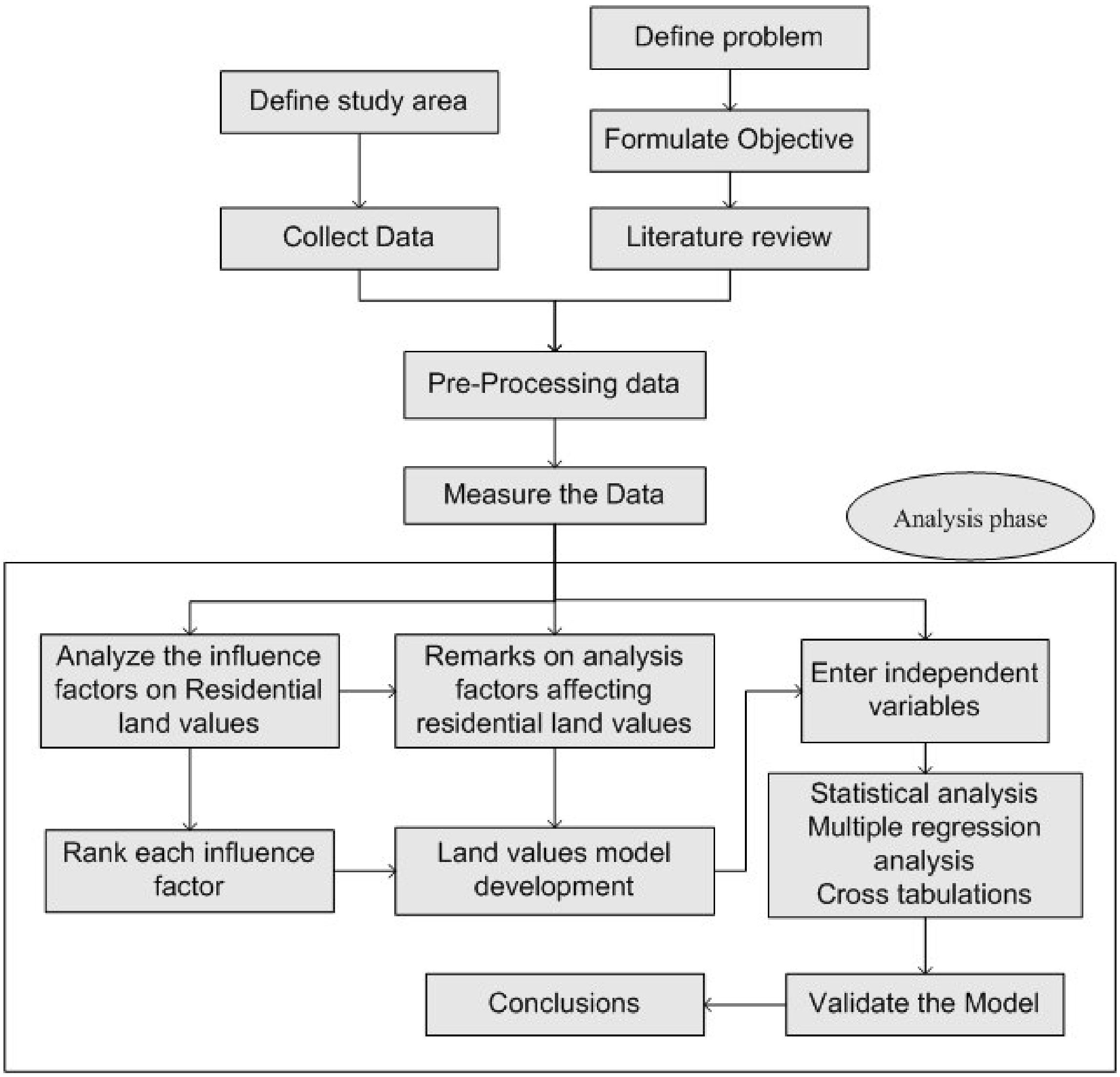

Figure 1-1: **Research flowchart**

1.6. Structure of the thesis

The thesis is composed of six chapters.

The first chapter, the topical context of this study is presented and some general information is given about land market in China, including the research background, problem statement, research objectives and questions. The research context of this study is clarified. Research framework is also described.

Chapter two gives a theoretical concept of land value and urban land market, methods and purposes of land valuation. Factors that influence the value of residential land will be identified. A traditional land valuation will be compared with the proposed concept of this research.

Chapter three describes the background of the study area. It focuses on land market and land reform in study area.

Chapter four explains the research methodology. How the study scope is selected and how spatial and non-spatial data are collected and measured. And pre-treatment data (dependent variable and independent variables) will be described and analyzed in this chapter.

Chapter five deals with data analysis and the results of the research. The market sale price of each variable will be analyzed. The relationship between the value and each variable will be tested by using statistical technique.

Finally, the conclusions and recommendation of the research are presented in chapter six. Conclusions are drawn from the research results and findings; it also includes recommendation for further study.

2. Overview on urban land value and models

2.1. Introduction

Urban land value has social, economic, environmental, and historic values. The spatial pattern of land value has been studied by various scholars and researchers; all of these models have showed a correlation with conditions of accessibility, and land use patterns. From the work of Hurd (1903), Wingo (1961), Alonso (1964), Muth (1969), and Mills (1972) to the current scientific and financial analyses land value pattern, passing through the so-called “neoclassical models” and its opposing proposals, they try to establish the more relevant factors controlling land value behaviour other than distance from the urban centre.

The purpose of this chapter is to review the theory of urban land value and give an outline of these models through history and shows their correspondence with urban residential land value field. In addition, concerned with the model of the land valuation to achieve the research objectives and testing model is explained here in detail. In the first section an overview on theory of urban land values is presented.

Based on certain assumptions, and the major factors influencing land values will be identified in the following sections. The model of the land values and accessibility theories will be introduced.

2.2. The traditional approach of urban land value

According to neoclassical marginalist models of Hurd (1903), Alonso (1964), Muth (1969), competitive bidding for land determines the pattern of urban land-use (Kivell 1993). As Rhind & Hudson has stated that for each type of activity, a location has utility which is measured by willingness to pay rent for use of that location. Activities bid competitively in a land market for use of different locations (Phe and Wakely 2000).In the long run, this competitive allocation process results in a tendency for the overall land-use pattern to adjust, so that, each location is occupied by the activity which can pay the highest rent. This yields an ordered pattern of land-use in which all activities are optimally located, in the sense that utilities are maximized (Adams 1994). Relative profitability and utility in neoclassical marginalist theory are determined by accessibility. From the supply and demand side, not every user can enjoy the most favoured land due to the limited supply or planning, physical, valuation or ownership constraints. Although owners may prefer to receive rent, if only on a short-term basis, rather than leave land and property vacant, for example, if the maximum price that developer are able to afford is below that which owners will accept, no sale will take place. Hence, marginal land has to be brought to use. These neoclassical marginalist models implicitly assume that land using activities have different needs to locate close to the centre of the city and will bid for land accordingly. This results in a gradient of intensities of land uses and land prices which declines outwards from the centre.

In essence, a landowner's income from land is formulated from original Von Thunen Model of agriculture land use; it also can be explained in urban land use as follows:

$$Pc(t) = N[Pc - C - Kc(t)] \qquad (1)$$

Where, *Pc (t)* is the rent per unit of land at a distance t from the market; *N* is number of units of crops produced per unit of land; *Pc* is the price per unit of crop at the market; *C* is cost of producing one unit of the crop; and *Kc (t)* is cost of transporting one unit of the product at a distance t to the market.

Such a budget equation sets the constraint on the land consumption alternatives open to each consumer or land user-group. Under such circumstances, land price at any particular location depends upon the nature of the activities, and this equation represents the surplus profit that a landlord is able to extract.

According to Alonso's notion, the bid-rent formulations rest upon the assumption that different activities will have bid-rent curves, which vary in form according to their need to be at the centre of the city. This, in turn, depends upon the nature of the activities; their ability to take advantage of highly priced central sites and their sensitivity to transport costs (Kivell 1993). This theory provides the rationale for the arrangement of land uses and values indicated in figure 2.1. In this graphic illustration, there are three activities, e.g. commercial activities, industrial activities and residential activities. A number of industrial activities have (and had even more strongly in the past) a need to be close to the centre for reasons of labour availability, transport services and marketing services, but their need is less than that for commercial uses and they are less sensitive to small variations in accessibility, therefore their rent gradient is less steep and they cannot compete successfully for the very central sites. Residential activities are normally the largest user of land in the city. They may desire a fairly central location (although suburban qualities are increasingly preferred), but they cannot derive sufficient utility or profit to outbid commerce and industry. In effect, they become a residual use, consigned to the lowest levels of the bid-rent curve with locations furthest from the centre.

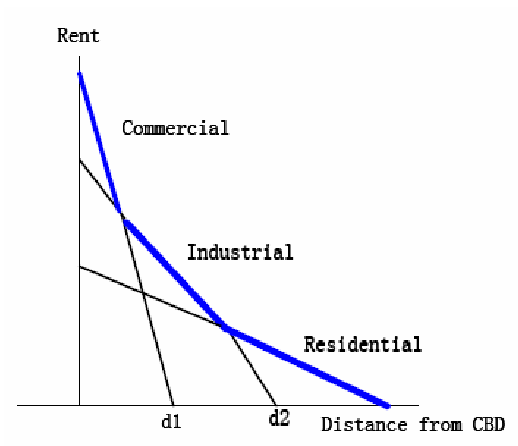

Figure 2-1: The model of urban land market by Alonso (1964).
(Source from Zheng (2003))

2.3. The classical models

According to the bid-rent theory, and the pattern of land use, which is assumed to result, provide a degree of explanation for one of the best known models of urban structure that of Burgess (1925). His model was derived from empirical observations of the way in which the city of Chicago had developed. As such, it is a hybrid of idealised land use patterns and urban social structure with a strong emphasis upon residential areas. The model is commonly represented as a purely concentric zonation of activities, see figure 2-2.

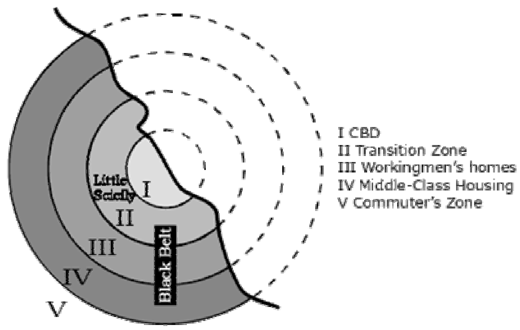

Figure 2-2: Concentric Zone Model from Hoyt, 1939
(Source from Pacheco (2004))

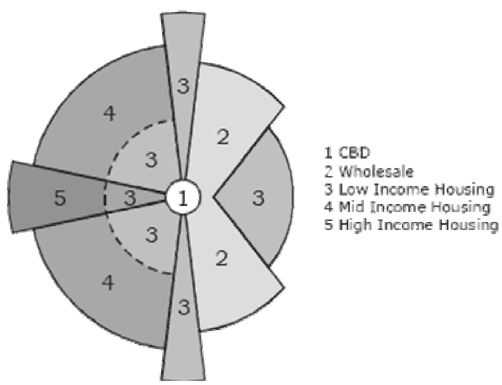

Figure 2-3: Sector Model from Burgess and Park, 1925
(Source from Pacheco (2004))

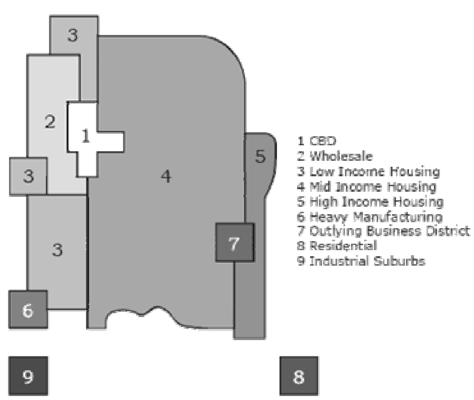

Figure 2-4: Multi Nuclei Model from Harris and Ullman, 1945
(Source from Pacheco (2004))

Moreover, the importance of a sectorial form of development was taken up by Hoyt (1939) in his study of residential rent levels in a large number of American cities, including Chicago (figure 2-3). The main difference between these two models is that Hoyt considered direction, as well as distance, from the CBD to be important in determining land use.

The arrangement of the sectors was such that high income areas were protected from low income districts and from industry by buffer zones of middle income housing. The strength of the sectorial pattern, which emerges, should not be allowed to disguise the fact that within the sectors, Hoyt clearly identified concentric zones of differential rent and a tendency for the most fashionable residential areas to migrate outwards from the centre along specific sectors. The processes differ, in that Burgess was largely concerned with social factors such as ecological competition and migration, whereas Hoyt concentrated upon amenity value and filtering. Empirically, Hoyt's model is to be preferred to that of Burgess because it is more firmly based in empirical data, being a synthesis of twenty-five cities, and because it goes further towards acknowledging that the CBD is not the only commercial focus of the city. This latter point is important because some of the rationale for identifying sectors was the growing importance of motor transport, which was creating subsidiary commercial nodes, often alongside major radial roads, in the interwar period.

In the third major model, Harris and Ullman (1945) extended Hoyt’s subtle recognition that the CBD was not the only focus of activity, and made it explicit in their multiple nuclei model (figure 2-4). The model incorporates elements of Burgess and Hoyt, but it is more flexible than either. Essentially, it implies that the city has a cellular structure within which a number of specialised areas develop. Some of these may be highly nucleated, such as suburban shopping centres, industry or high income housing. In relaxing the dominance of a single centre, and the assumptions of general accessibility to the core, the multiple nuclei model recognises the interaction of three main elements of locational factor. First, it gives some weight to topographical and historical features in the origins of the growth of the city, for example, in the absorption of minor settlements. Second, it recognises that different levels of retailing do not all seek a central site, some preferring suburban locations closer to their market. Third, it allows for the agglomeration economics and both the negative and positive externalities, which cause certain firms or households to cluster together (Kivell 1993).

From above three models, these have well established urban structure in North American that they are normally referred to as 'the classical models'. Subsequently, Mann (1965) attempted to refine them for the British context. His diagrammatic model draws most heavily upon the concentric zone and sector models, but it makes passing reference to separate and more specialised areas. Especially it also makes allowance for public sector intervention in the form of local authority housing (figure 2-5).

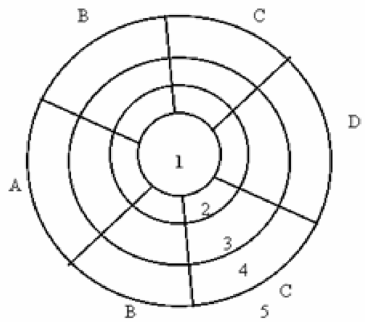

Figure 2-5: Model of Urban structure-Mann, 1965 (Source from Turkstra (2003))

2.4. The contemporary approach of urban land value

The uneven distribution of land values has attracted numerous studies as dynamic urban development has continuously challenged our understanding about the pattern of land value distribution and the determinants underlying the patterns. Recently, more scientific as well as financial analyses have been employed to try to establish the more relevant factors controlling land value other than distance to city centre. For example, accompanying the high-tech development and spread, it makes sites further from the economic centres more accessible the land value increases, especially at sites further away in distance but now closer in terms of travel time. Values around nodes, interstate access points, or light rail stops will increase the most as long as zoning and other land use regulation permits more intensive development around such sites (G.Miller and Geltner 2004). Additionally, Physical determinants of land value distribution form one group of dynamic factors. Indeed, in early 20th-century Chicago, 75 percent of land value variations was explained by the distance variables alone. In the 1960s, however, distance variables could only explain 10 percent of the variation in land value in Chicago (Yeates and Garner 1971). Furthermore, Norman G. Miller and David M. Geltner presented that real world cities are not purely monocentric; they have other major activity areas besides the CBD. Large cities are sprinkled with neighbourhood business districts (NBDs) that serve needs of local communities (figure2-6). Governmental and public services of the central city are usually not decreased in line with fewer residents. In most American cities, the middle and upper income population has largely left the central urban core, placing most purchasing power in the suburbs. Increased transportation costs caused by traffic congestion further disperse households and jobs. Similarly, the studies in developing country city, from Sun's research to Dowell's research, all of them confirm that residential land values were not only related to exterior attributes, distance, infrastructure but also title of registration; and land values in Jakarta were not uniformly distributed among the various parts, with high land values in central areas and low values further away from the CBD. Land price increased faster in suburban areas than in central-city areas. Their statistical analysis yielded supportive results to claim that distance to CBD, availability of infrastructure and title explained land value variations. The distance variable alone explained 62 percent of the variations, while the addition of the other two variables only raised the explanatory power to about 69 percent (Han and Basuki 2001). Furthermore, Ravallion (1989) constructed a price index for each municipality in Jakarta and evaluated the influence of physical and locational factors on housing price, as well as land price. However, even with the shift in economic activity to sub-centres within the urban area, the city centre will likely remain an important part of the structure of land values. In polycentric urban areas, researchers control for the impact of the sub-centres by using a continuous inverse distance measure such as a negative exponential function or, alternatively, by using a dichotomous variable to identify whether a property falls within a certain radius of the sub-centre (Nzau 2003; Zheng 2003).

The result of this is that the coefficient of distance to the CBD in a regression explaining land or property values can be of either sign. They conclude that the actual residential land price function can exhibit complex curvilinear shapes, and hence land prices may not automatically decline with distance from the CBD.

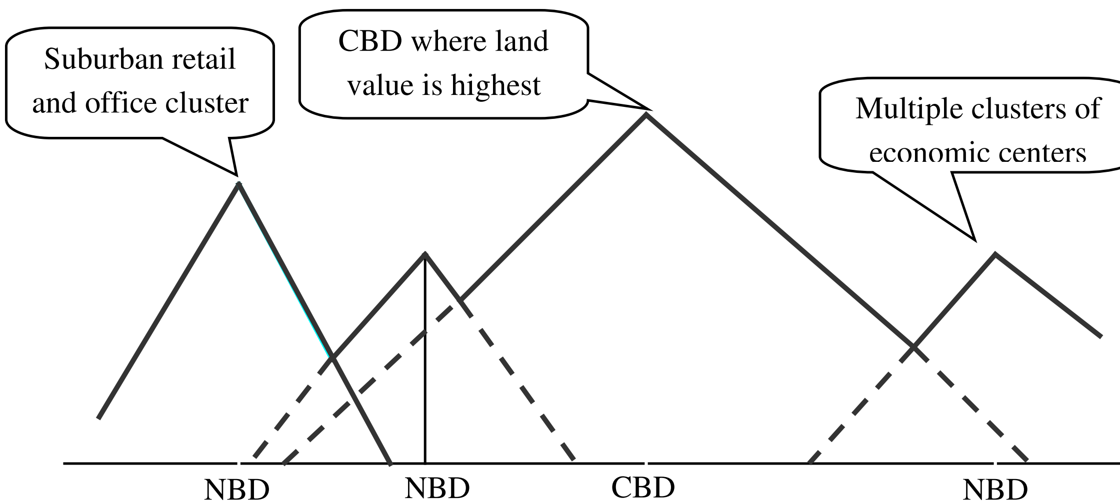

Figure 2-6: Polycentric or multiple nuclei cities

From above analysis, the contemporary approach of land value embodied the discounted present value of all locational amenities and disamenities. These all implicate three necessary conditions that need to be satisfied in order to assume that the full cost of amenities is captured in real estate values. Firstly; real estate markets must have many buyers and sellers, with no dominant agents on either side of the transaction. Secondly, buyers and sellers of real estate must be fully aware of the amenities and disamenities associated with the location of each property. These first two assumptions are the typical perfect competition requirements of large numbers and full information in the market-place. Thirdly, other variables that affect real estate values are measurable. For example, many studies have analyzed the captured value of improved accessibility. The effect of a transit system on real estate value appears to satisfy all three conditions. Indeed, empirical studies have confirmed the close association of transportation savings with differentiated values of properties. Boyce et al. (1972) showed that the market values of single family homes which have access to a transit system are higher than of homes which are less accessible (Diaz, Booz.Allen et al. 1996). An accessible home's market value is higher than that of a similar, less accessible home by the discounted present value of the commute value of time saved, ceteris paribus.

Clearly, these savings diminish as the real estate is located further away from the transit station. That, in turn, leads to a proportional decrease in values (Pivo 1993). Similar studies have analyzed the capitalization of disamenities like air and noise pollution (Freeman 1979; Espey M and H. 2000). As an example of noise pollution, market values of homes were recorded at various distances from a commuter railway while controlling for other locational and physical characteristics.

The land supply and demand

Besides having physical and locational characteristics properties, the properties also have temporal characteristics for example, Land supply and demand change over time. In general words, the price of land depends on the actual and expected rate of growth of the city and the increase in employment in the city centre which leads to an increase in the demand for urban land or optimal utility of the urban land. Such increases in demand further lift the premium required by the agricultural owners to give up their land for development and a relatively small amount from redevelopment. With this high price of land for a particular use (e.g. agricultural use or low class residential use) will be converted into the former use. This will reduce the supply of land for other uses; their land price will be driven up. Land price is not only determined by demand of the product on land, but also by the factors affecting land supply such as ownership and land tax. In Louis A. Rose analysis, he confirmed that the average of all market rents should be positively related to the urban area's population. A higher population implies a higher demand for land and housing in each market as well as an expansion in the number of markets containing residential units (A.Rose and Croix 1987). Secondly, the average rent in an urban area should be positively related to the real per capita income of residents. At higher real per capita income, individuals demand more housing, and especially more land. This is confirmed by Harris, Tolley, and Harrell (1968) who estimate an income elasticity of demand for residential land.

2.5. Alternative methods for assessment

What are needed are the approaches to appraising land that can be used to predict the market land price, which would give planners, decision makers and real estate developers a powerful tool for determining the property tax and valuing properties, indirectly, the vitality of local governments.

Since about 1910, three approaches to estimating market value have been refined through the years and variations developed for specific appraisal problems (Eckert 1990). They are:

2.5.1. Sales comparison approach

The sales comparison approach, it assumes that the market value is equal to the price recently paid for a similar property or interested in land. The valuer's problem is to determine what the market considers to be recent and similar. Adjustments may need to be made for differences between the properties used in the comparison and changes that have subsequently taken place in the market or are of a structural nature. If an almost identical house were recently sold next door for a known price but which lacked a particular facility such as a garage or central heating, then slightly different assessment would be expected. The approach is often the most simple and efficient means of determining market value, especially for single-family residential properties in an active market (Dale and Mclaughlin 1988).

2.5.2. Cost approach

The cost approach, it is also known as the contractor's method or the quantity survey approach. It assumes that the costs of replacement, less appropriate depreciation, are equal to the value. The problem is to assemble suitable cost data, including the cost of the site, and to estimate depreciation rates. The method is particularly useful for insurance purposes, where the cost of site clearance may be added to cover the possibility of a building being destroyed by fire, and for valuing new constructions (Dale and Mclaughlin 1988).

2.5.3. Income approach

The income approach, it is also a comparative method and holds that the market value of an interest in land is equal to the present value of the net income that should in future come from the land. The net income is the gross income less the cost of overheads, such as depreciation of the building stock and its maintenance and upkeep. It is equivalent to a national rent and must be discounted at an appropriate rate. The valuer's problem is to determine the net benefits that should come from the land by comparison with similar properties; and then to determine the market discount rate by analyzing recent sales of similar assets (Dale and Mclaughlin 1988).

2.5.4. Comparison of the valuation methods

All three methods used to determine market value, the sales comparison approach, the cost approach, and the income approach, are market oriented and must reflect market data and the market behavior of buyers.

Using the sales comparison approach, the market value is determined by adjusted the sales prices of recently sold similar properties (comparables). The sales prices of the market comparables reflect the behavior of typical buyers in the marketplace.

With the cost approach, market value is determined by calculating the replacement cost of an identical home plus the cost of the land underneath the home minus any depreciation over the years since the home was first constructed.

The income approach analyzes the market rents of comparable properties and applies the gross rent multiplier in relation to expected rents from the subject property to determine the market value.

The sales comparison approach is the generally preferred approach to valuing land and residential property. Assessors across North America are making expanded use of automated sales comparison models, especially multiple regression analysis. These techniques have powerful advantages in terms of keeping values current and ensuring uniformity. Thus, in this research, the sales comparison approach has been selected to analysis the residential land value in Hankou.

2.6. Comparison approach

2.6.1. Model specification

A general sales comparison model is:

$$MV = S_c + ADJ_c$$

Where MV is a market value estimate, S_c is the sale price of a comparable property, and ADJ_c is the total Rmb adjustment to the sale price of the comparable for quantitative and qualitative differences between attributes of the comparable and the subject property (Eckert 1990).

2.6.2. Selecting the comparables

Three to five comparables are usually adequate, but a larger number improves confidence in the final estimate, increases the awareness of patterns of value, and stabilizes assessments over time. Sale and subject should be similar with respect to date of sale, economic conditions, physical attributes, and competitiveness in the same market. Of these, the most important is competitiveness. If the comparable and subject do not compete in the same market, they do not face the same supply and demand forces, so value inferences from comparable to subject may be misleading (Eckert 1990).

2.6.3. Determining the attributes

Attributes, the characteristics of a property, are such things as the size, land use. The sale price is a function of how buyers and sellers perceive the utility of important property attributes. The importance of an attribute is known only after the data have been analyzed. Therefore, more attributes are usually collected than are needed for valuation. In this case, the attributes have been decided by the export opinion and from reference to the benchmark report in 2004.

2.6.4. Relationships among adjustments and attributes

Two kinds of relationships must be specified: (a) how the attributes (and, therefore, adjustments) relate to one another. Are the adjustments to be added together to form a total adjustment or are they to be multiplied, or some combination of the two? (b) How changes in quality and size of an attribute relate to changes in value. Does every square meter added to the size of a property make the same marginal contribution to value? e.g. whether the attributes are linear related or nonlinear related.

2.6.5. Calibrating the sales comparison model

During model specification, the significant attributes and the relationships among the attributes have been determined. The coefficients are determined during model calibration. Paired sales analysis, multiple regression analysis, adaptive estimation procedure, and the cost method are often used to calibrate sales comparison models. Here, multiple regression analysis has been expanded on my research.

2.6.5.1. Multiple regression analysis

For the multiple regression analysis (MRA), unlike paired sales analysis, regression does not require strict similarity between properties. Regression analysis identifies the degree of importance in each of the variables and shows how well the model itself performs as an estimating device. The general model is:

$$Y = \beta_0 + \beta_1 X \quad + \beta_2 X_2 + \ldots + \beta_k X_k + u$$

Where Y is dependent variable (sales price); X_k are independent variables k (characteristics of the property); β_k is implicit price of characteristic k; u is error term.

MRA tends to work well when sales are plentiful enough and property characteristics are accurate. Predicted values are particularly accurate for parcels with typical characteristics. However, predicted values for parcels with atypical characteristics usually have a high margin of error and should be field reviewed (Eckert 1990).

The objective of MRA, as applied to mass appraisal, is to model the relationship between property characteristics and value, so that the latter can be estimated form the former. For example, the relationship between land price and land area can be investigated from the data on square meters of land area and land sale price. These data are graphed and a straight done to generate line in figure 2-7.

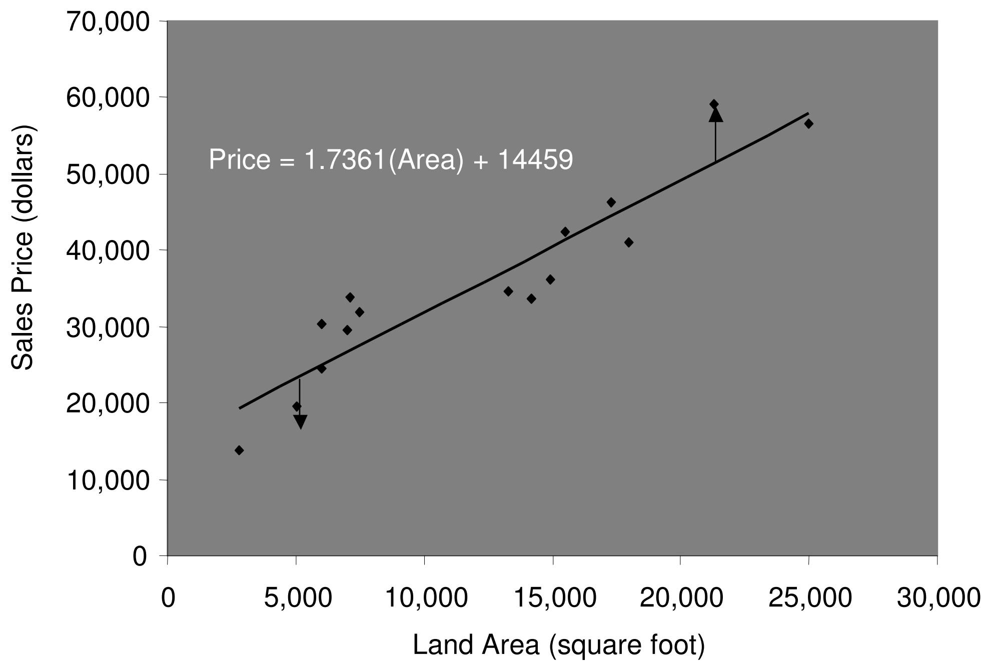

Figure 2-7: The correlation of sale price of land and land area (Source from Hong (2001))

2.7. Selection of the sale comparison approach in residential land value modelling

2.7.1. The specific land market situation in China

In this study, it couldn't be omitted that the land market mechanism drives land use allocation and optimal utility of scarce land. In developing cities, it exist problem in land market. Especially in China, Many land-use problems in Chinese cities were deeply rooted in the land tenure system that was adopted since 1949. In cities, the state confiscated land and proclaimed state ownership. The state allocated land-use rights free of charge to socioeconomic units, called Dan Wei. Since these Dan Weis were also state-owned, land-use rights and land ownership were institutionally inseparable and land transactions were considered unconstitutional. Land markets virtually vanished. The location and amount of land allocated to a Dan Wei depended on its political connections as well as the political environment in which socioeconomic functions and productions were planned and organized (Ding 2002). The lack of economic and administrative channels for the transfer of land-use rights and ill-defined property rights not only resulted in land-use deficiencies but also created social conflicts and land disputes.

Although, the land value has attracted many researchers to systematical analyze. In China, land was considered neither as a commodity nor as an asset for producing economic wealth. The state owned all urban land and allocated it to the work units. Since China's reform and opening up, significant changes have taken place in China's land market, and the revolution on supply of land started in 1987 and lasted for over a decade and experienced three climaxes: The first climax of China's system of land use was started when the system of no compensation and no time limit in supply of land was terminated and land began to enter the market as a commodity at the end of 1980s. From the land lease under government approval in Shanghai and the first auction of land use right in Shenzhen to the following modifications made by the constitution of the People's Republic of China on land lease and transfer. In 1998, the Ministry of Land and Resources issued the Circular on Further Promoting the Assignment of Right of Stated-owned Land by Tender and Auction. The bold promotion by the local governments and the active guidance by the Ministry of Land and Resources jointly contributed to the second climax in land market establishment. The third climax in reform of land use system was occurred during the period of the Ninth Five-year Plan and the third after the Tenth Five-year Plan especially in 2001. It further improved the land market mechanism and remarkably displayed the fundamental functions of allocation of land resources through market mechanism, meanwhile played an important role in standardizing the examination and approval of land and rectifying the market economy order. The basic systems ensuring the standard operation of land market serve as important tools in standardizing land market order. Under the guidance of those land laws and regulations, the right of state-owned land resources quickly shifted from examination and approval to auction resulting in a further standardization of land market. Up to 2001, the promulgations of a series of local regulations and standard documents helped initially establish and improve the systems of controlling total supplies of land for construction purposes, centralized supplying of urban lands for construction purposes, public transaction of land use right, regular renewal and promulgation of standard land prices, public inquiry for land registration and collective decision-making.

Currently, although a number of ways are in operation to form a free land market system in China, the centrally planned system continues to predominate. This dual structure in China's land market consists of the controlled market and the free market. Hence, this imperfect market was influence on the market land value and bias the economic market system. Inevitability, it would be influence on the model of land valuation. Meanwhile, the market supplying of residential lands has developed dramatically in recent years; spatial residential land value has changed very frequently, hence, the land valuation is necessary to systematically analyzed in this phase. In other words, the benchmark price should be updated in certain period.

2.7.2. The specific of the residential land value

For residential land use, the property is a multidimensional commodity, characterized by durability and structural inflexibility, as well as spatial fixity. Each residential unit has a unique bundle of attributes: its accessibility to work, transport and the amenities, and the structural characteristics, neighborhood and environment. A variety of theoretical and econometric studies have explored the relationship between house prices and location quality such as Freeman (1979), Serim Huh and Kwak (1997), Tse (2000), and Tse and Love (2000). Traditional location theory examines the effect of accessibility to central locations on house prices, and states that housing and accessibility to employment centers are jointly purchased in that those paying higher prices are compensated by the lower costs of commuting to the central business district (CBD). As house prices increase, households tend to move to locations with inferior accessibility, where prices are presumably lower. However, the housing market is an inherently dynamic and stochastic entity. The relationship between house prices and locational factors is the result of unobservable variation in the location across properties coupled with the heterogeneity of the market. For instance, better-quality properties could reflect the quality of the location that in turn induces more good-quality property to be developed in that location such as Phe and Wakely (2000); Larry and Thibodeau (1983) argued that higher-income metropolitan areas have proportionately more new houses of better quality and larger size, which would be reflected in higher median prices, even if houses of equivalent size and quality are priced similarly to those in lower-income areas. Amenities like a better environment are locally specific. Thus, inter metropolitan variations in levels of these amenities could also contribute to inter metropolitan variation in housing prices. This generates a bias in the Ordinary Least Squares (OLS) estimates of the cross-sectional housing price equation. Most empirical work on the hedonic house price model has ignored methodological issues that might result from the spatial nature of data sets. For example, the simple monocentric model/density gradient approach does not take into account the fact that attributes other than distance vary across space and that we need to be concerned with spatial autocorrelation, as well as temporal autocorrelation. But for the recent established land market regulation in China, the accuracy data of residential land sale prices are short in land market. Hence, we couldn’t extend the analysis of temporal autocorrelation for residential land values.

2.8. Common land value model attributes

According to above analysis, the main attributes of the land value model can be summarized as follows.

2.8.1. Accessibility

In neoclassical models, the accessibility to city centre was definite the measurement of the bid-rent curve. Various different measurements have been implemented to capture the effect of accessibility with differing results. Straight-line distance to the CBD has been the usual measure, with linear or semi-log functional form, with a recent shift to road distance. Physical distance is not the only measure of accessibility that has been used. Accessibility in terms of journey to work time, travel time and monetary loss has also been considered. Similarly, Specifications of accessibility indices have ranged substantially: from simple minimum travel-time indices (e.g. (Leake and Huzayyin 1979); (Helling 1999)), to measures of cumulative opportunities within specified distance or time thresholds, to maximum utility measures (Issam M. S, Kara M. K et al. 2001). From the perspective of land markets, rents paid to purchase land may make great sense as a measure of access. The value of access is capitalized into the land value and access is measured in market participants’ willingness to pay. For an accurate measurement of the accessibility of a location, thus, four types of accessibility measures have been summarized as follows:

1. Distance measures, it is the “relative accessibility” measure. It is defined as the degree to which two places or points on the same surface are connected. The simplest measure of relative accessibility is the straight line between two points. The measure can be used if the destination is known, e.g. in the case of a daily return to work place. If more than two destination are analyzed (the accessibility of one place of point to all other places), a contour measure can be derived.
2. Contour measures, it indicates the total number of destinations reachable within a given travel time or distance and does not discount opportunities over distance. e.g. this measure emphasizes the number of potential destinations or opportunities rather than their distance. The main advantage of the measure is that it presents an easily explainable accessibility measure without

implicit assumptions about a person's perception of transport, land use and the interaction of these two. Furthermore, the data for the measure are comparatively readily available, making it possible to study different kinds of access by different types of people for different activities, which are relatively undemanding of data. The disadvantages of the contour measure are the implication that all opportunities are equally desirable, regardless of the time spent traveling or the type of opportunity

3. Composite measures, this is the best-known composite measure based on the potential values, which are related to the gravity model. The gravity model is based on an analogy between the interaction of groups of people and the attraction of physical masses.
4. Utility-based accessibility measure, it is describes the utility inhabitants derive from potential accessibility to destinations, using an impedance function for travel cost. It is assume that each destination in a choice set has a total utility and that each individual will select the alternative that maximizes the total utility. An important advantage of the utility-based measures is that it has a sound theoretical basis, e.g. the random utility theory on which these measures are based provides a direct link to traditional microeconomic welfare theory (Yi 2004).

For the distance measures, it measures straight-line distance, which cannot give an accurate description of the reality. For composite measures, a parameter value for the travel impedance function must be selected or estimated using recent empirical data of spatial travel behavior in the study area, and the measures are based on aggregate travel patterns. For the utility-based measures, they overcome the shortcoming of potential accessibility that represents accessibility of a location or zone, assuming all individuals in the same location have the same level of accessibility. On the contrary, the contour measures are more appropriate than other measures. In contrast to the potential value, the contour measure is stable, also in the neat vicinity of data points. More importantly, both the contour measure and its parameter, the distance range, are easily interpreted in real-word terms. In the context of finding a suitable location for one or more service outlets, it is not accessibility itself, but the expected number of customers that is the determining factor. From the accessibility to activates.

2.8.2. Neighbourhood quality

In addition, Neighborhood quality we couldn't neglect its function. The land value is strongly related to the social and economic characteristics of the neighborhood, including the presence of such amenities as views, parks, schools and community services. A good land valuation study has to include neighborhood quality measures, at as disaggregated a level as possible. If each neighborhood has its own effect, the land value model would ideally need a separate indicator variable for each neighborhood. However, identifying all relevant neighborhood characteristics within urban areas is difficult. It is only when such data are unavailable that other methods would be sought to control explicitly for such variation. Most of the effort in spatial statistics focuses on modeling the dependence of errors in a valuation equation. From measurement side, there are two potential sources of spatial dependence: structural spatial dependencies across observations on the dependent variable and spatial dependence across error terms (Bell and Bockstael 2000). Structural dependence arises, for example, when the selling price of a house reacts directly to the selling price of another neighboring house and not just to the characteristics of the surrounding houses. By contrast, spatial dependence among the errors is generally due to omitted variables, which are spatially correlated themselves, or due to errors in measurement that are systematically related to location. Spatial autocorrelation is likely in a hedonic house price model, because houses located in proximity to one another will have similar unobservable attributes, where not all such attributes are included in the hedonic price model. A feasible approach to the use of hedonic regression is to choose a sample of households with similar locational characteristics and incomes and, implicitly, homogeneous tastes, so that the net effects of various internal attributes and environmental factors of the neighborhood are locationally insensitive. Bailey et al. (1963) suggest combining the hedonic and repeat sales methodologies in order to correct sample selection bias. Even if a sample with similar locational characteristics is chosen, house prices tend to be spatially autocorrelated because neighborhood residential properties share public infrastructure and amenities. There will be a set of spatial spill-over effects on a given residential structure from the physical quality, as well as the uses associated with the surrounding neighboring structures. These adjacent effects will ultimately be capitalized into the nearby housing prices and thus will lead to spatial dependence in the housing price determination process.

2.8.3. Environmental quality

Last but not least, it is more and more important for the residential located. The price paid for a property directly reflects the benefits of the characteristics of the property. In this way, environmental characteristics such as clean air, peace, quiet and beauty are traded in the property market. Similarly, Changes in noise level can lead to changes in enjoyment of an environment. When the noise levels are sufficiently high, they will impose costs on individuals and these costs may decrease house and land values. Abelson (1979) related the land value associated with houses in the Marrickville and Rockdale suburbs of Sydney to noise level and other characteristics such as house size. The average unimproved land value of a house block at the time was US$10 000 in Marrickville and US$14 000 in Rockdale. Abelson's findings included that a one unit increase in aircraft noise that is a one unit increase in the Noise Exposure Forecast, decreased land values by between US$540 and US$840 in Marrickville and by US$300 in Rockdale (Source from: http://www.deh.gov.au/pcepd/economics/value/chapter4.html).

3. Background of the study area

3.1. Introduction

3.2. Wuhan city

Wuhan, one of the 10 largest cities in China as ranked by total retail consumer spending (No. 5 in 2002) (figure 3-3), output of gross National product (No. 9 in 2001), and total fixed asset investment (No. 9 in 2001) (Wuhan statistical bureau and Wuhan development and planning committee 2002), is situated in the centre of China (figure 3-1). Locate in the intersection between the Yangtze River and the Hanshui River (figure 3-2). Simultaneously, Wuhan is a strategically place of economic and load center since that it is the centered of a series of concentric rings. Urban settlements in Wuhan can be traced back to the Shang Dynasty (16th-11th century BC) of 3500 years ago. Historically, Wuhan was described as “center of the whole Empire, and the place from which it is easiest to keep a communication with the rest of the provinces” (Han and Xiangwu 2004). Today, Wuhan city has grown into a key centre of industry, finance, science and education in central China. It has experienced rapid growth in economy, infrastructure, and standard of living over the past five years, with its GDP averaging a 10% increase per year, whilst population growth was low at 2.4% in urban area (appendix 2). For several years, Wuhan has been ranked No.6 in the top 50 cities of China for comprehensive economic strength (Census statistic bureau of Wuhan city 2004). The GDP of 2003 reached 166.2 billion RMB, grew by 10% than that of last year (appendix 1). The total urban area of Wuhan city is 8,549 km^2; the estimated population of the city was 7.8 million by 2003, giving an overall population density of 914 persons per square kilometer. Accompanied with economic development and living condition improvement, the total new real estate construction area is 19.55 million m^2 in 2003. Its increase rate is 17.0% compare with that of 2002. The complete construction area is 6.82 million m^2. The increase rate is 7.8%. Among of the area, residential construction is 6 million m^2, increase rate 14.8%. The total sale commercial house area is 5.43 million m^2, increase 20.5%. Meanwhile, the whether of Wuhan city is also suitable for the residents living; the geographical position of Wuhan is 30°33’N and 114°19'E. Its climate is subtropics, characterized with humid monsoon. The four seasons in Wuhan is distinctive and her annual frost-free period is about 240 days.

In general, Wuhan urban area consists of three parts (Wuchang, Hankou and Hanyang) and separated by two rivers (Yangtze River and Han River). Wuhan is a multi-center city and is the capital of the Hubei province. The urban development of these three parts has each unique characteristic. Hankou has been a historic commercial town for more than 300 years (Han and Xiangwu 2004). The proportion of commercial land use type is higher than those of Wuchang and Hanyang. Hanyang has lots of historic attractions. A number of heavy industry sites are locating in Hanyang. After the foundation of Wuhan city in 1949, Wuchang was supposed to develop into a town for regional cultural and higher education facilities. More than 20 universities and colleges have been built in this part (Yinghui 2002).

Figure 3-1: Location of Wuhan city

Figure 3-2: **The districts of Wuhan city and case study area**

3.3. Hankou town

In this research, allowing for the time, and the availability of the useful data, the study area is focus on Hankou town. As the suitable residential area in Wuhan, the life style of Hankou is more attractive than other 2 towns; and the local persons prefer to live in Hankou town. From analysis side, the theoretic of urban land use structure, the location of CBD is definite measurement of land value, for the location of city center in Wuhan lead to choose Hankou town as the study area.

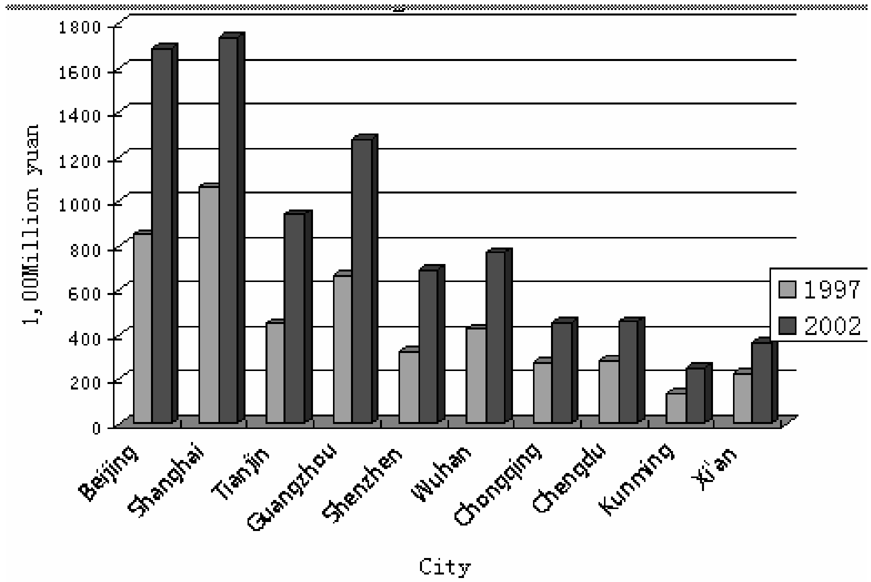

Figure 3-3: Total retail sales of consumer goods by selected cities in 1997 and 2002

Hankou town is made up of three districts: Jiang'an, Jianghan, and Qiaokou. As shown in the figure 3-2, the town is situated in North-west of Wuhan, and surrounded by two rivers. Moreover, there are many of the lakes distributed in this area. That means Hankou town has been dispersed to fragments. Especially, the site near the water is favor of the real estate developers. Because the water is the symbol of the treasure, and the treasure are flowing as river. The town covers an area of 144.06 km^2. And the total population of Hankou town has reached 1.63 million at the end of 2003. Compared with other two towns, the immigrated population is increased faster. At present, it has made up of political, financial& commercial, information and culture centre of Wuhan city. It also has a good urban traffic network and a developed intercity transportation. Within the town, there is Jing-Zhu (Beijing to Zhuhai) expressing way, railway station, transportation port, transportation station and Tianhe airport near by the west of the town.

3.3.1. The study area and the sub-centres

Hankou town is a plain area and the similar as triangular form, which is encircled by two reveries. The study area includes one city centre and 17 sub-centres. The city centre was established before 1980. It includes shopping centre, high-level hotels, museum, financial institutions, and businesses and offices. The 17 sub-centres were defined as an area planned and designated for commercial use and with high levels of both employment and economic activities than neighbouring areas. It should have a high concentration of different establishment including financial institutions, businesses and offices. For example, Hanxi sub-centre is the market to provide with the house decorative material; the Beihu sub-center is the financial and shopping centre to face the high income consumer or business man; Zhongshang sub-center is the historic shopping center, it caters to each level of consumers, especially for young people; Han zheng road sub-center is the store department center, it has both of wholesale and retail business; Zhuyeshan sub-center is auto manufactory center, the main business is to provide auto accessories; Youyilu sub-centre is the large scale wholesale store of flower; Bookstore centre is situated at Sanyanqiao road; it has large scale of wholesale stores and retail stores; etc. For the reasons of large labour capacity and its strategic location, Hankou is important commercial centre in central cities of China, as well as Wuhan city. Figure 3-4 shows the location of sample parcels, city centre and sub-centres. Five sub-centres and city centre are situated in Jianghan district, and 6 sub-centres are located in Jiang'an district, rest of 6 sub-centres are located in Qiaokou district.

3.3.2. Neighbourhood quality

The study area consists of 46 neighbourhoods (street Banshiqu), and the population density and income which, various in each neighbourhood, as shown in appendix 5. The table of classes of neighbourhood quality, it shows the general social economical distribution of the Hankou town. On the other side, each neighbourhood has unique characteristic. For example, Huaqiao is situated of the government and high-income residential area, has the good security environment. Taibei is situated in the low and middle-income residents, it has good education environment. Yongqing is situated in area of heritage building and old residential, but on the side of the river. There is new high-income residential area, with good education environment. Hanzheng is situated in the old residential area with poor quality of buildings and high density of population; most of residents are business man. The bad quality of neighbourhood, Hanshui is poor and migrant residential area. It is near Hanzheng neighbourhood and on the side of Han River. The classification criterion of the neighbourhood quality has been introduced (section 4.5.3.6). Here, the population distribution also has been classified by distance to city centre. From the figure 3-5, it shows the population achieve the peak at the distance of 4 kilometres to the city centre, but the high population density is at the distance of 2 kilometres to the city centre (appendix 6).

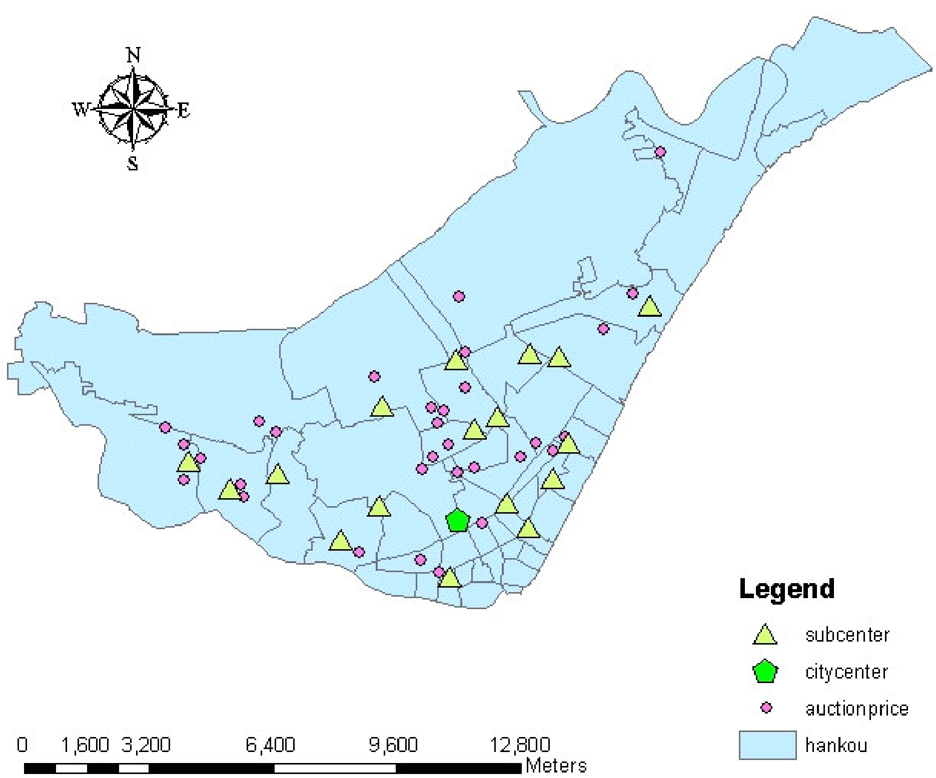

Figure 3-4: Location of sample parcels, city centre and sub-centres

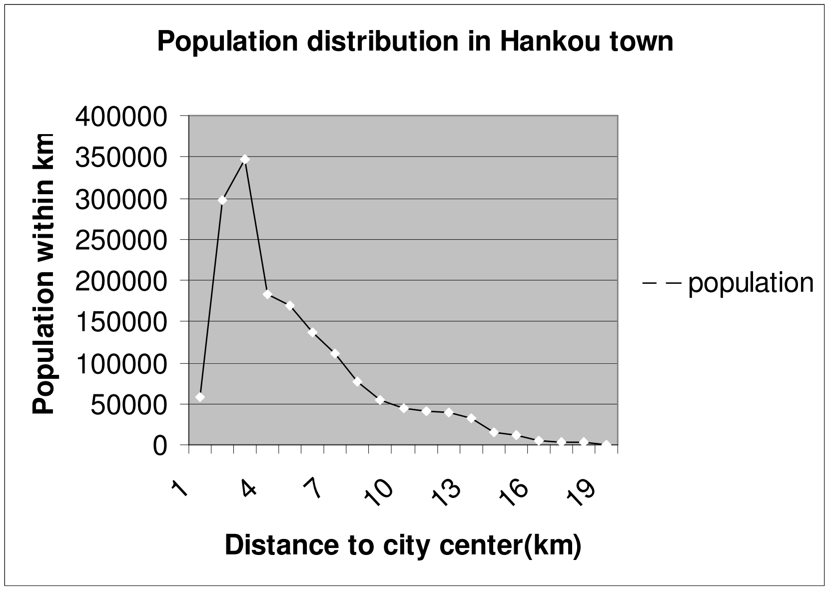

Figure 3-5: **Population distribution in Hankou town**

3.3.3. Urban land market

In this research, the actual price which buyers or sellers are forced to buy or sell the vacant land for residential use in land market, is main object of my case. From previous chapter, the development of land market in China has been reviewed. As Wuhan, the development of the land market is the recent implement of bid an auction in the urban land market. In 1999, the land and resource administration department proclaim the "ordinance of the further implement of bid and auction of land-use right in state-owned urban land". The ordinance has realised that to some extent, too much negotiation land-use right transactions conflict with the function of the land market in resource allocations, thus hinder improve economic efficiency, to correct government failures in land allocation, and to minimize negative consequences of the land tenure system. And the ordinance required the commercial, tourist; recreational, commodity house and villa for residential uses, all of these urban lands must be auctioned in the open land market. After the local government implemented the ordinance and established the land market transaction bureau in municipality in 2001. The first open land auction took place in March. 2001. Consequently, the land market has been extended frequently in the whole Wuhan city, include the county. The land valuation system has been improved in 2004. The new benchmark price is the guidelines of the land planning, land tax collection, and land sale price.

3.3.4. Housing reform and residential land-use right transfer

The establishment of a market-based housing system to privatize housing is the ultimate objective of China's housing reforms. Increasing rents has been the major step adopted so far since the housing reforms started in 1979. China has experienced many changes when the country embarked on a major economic reform. As one of the largest welfare sector, housing is the most important part of the economic restructuring process. After twenty years of experience, the welfare housing system has been changed and a new market-oriented housing system is growing. Along with these 3 stages below, a private housing market is now emerging in urban China.

- First stage of housing reform (1979-1988)
  - An experimental stage when changes were carried out in a piecemeal fashion and in only a few targeted cities.
- Second stage of housing reform (1991-1997)
  - Comprehensive housing reform programme was put forward and the policy to privatize housing stock became one of the most important housing reform policies.
- Third stage of housing reform (1998-present)
  - To establish a system in which the production, distribution, exchange and consumption of urban housing are driven by the market.
  - Housing Provident Fund (HPF) and Personal Mortgage have been used to promote home ownership.

Three different types or sectors of private housing have emerged in this market, according to the original nature of the housing.

- Commodity housing traded openly both in the primary and secondary market;
  - Commodity housing is dwellings constructed for sale by the development companies.
- Resale privatized public housing in the secondary market;
  - Public housing includes housing both provided directly by the State and indirectly by state-owned work units.
  - Work unit is the basic units of social organization in China and has many more functions than a place to undertake one's work or profession.
- Resale Economic & Comfortable housing in the secondary market.
  - "Economic & Comfortable" housing is aimed at the low-income groups. There are restrictions or penalties on resale and it is a form of quasi-ownership likely to inhibit mobility and exchange. But from 1998, the government has been considering gradual relaxation of resale restrictions so that the bulk of these housings can re-enter the market after a certain period of time (Xie, 1998).

From above analysis, the traditional structure of public housing provision in China can be drawn as follows figure 3-6:

The state here refers to the supervisory governments of state work-units; Labour (I) refers to workers and staff of state work-units; Labour (II) refers to workers and staff of small enterprises and local agencies that cannot receive CCI from the state, as well as private businessman.

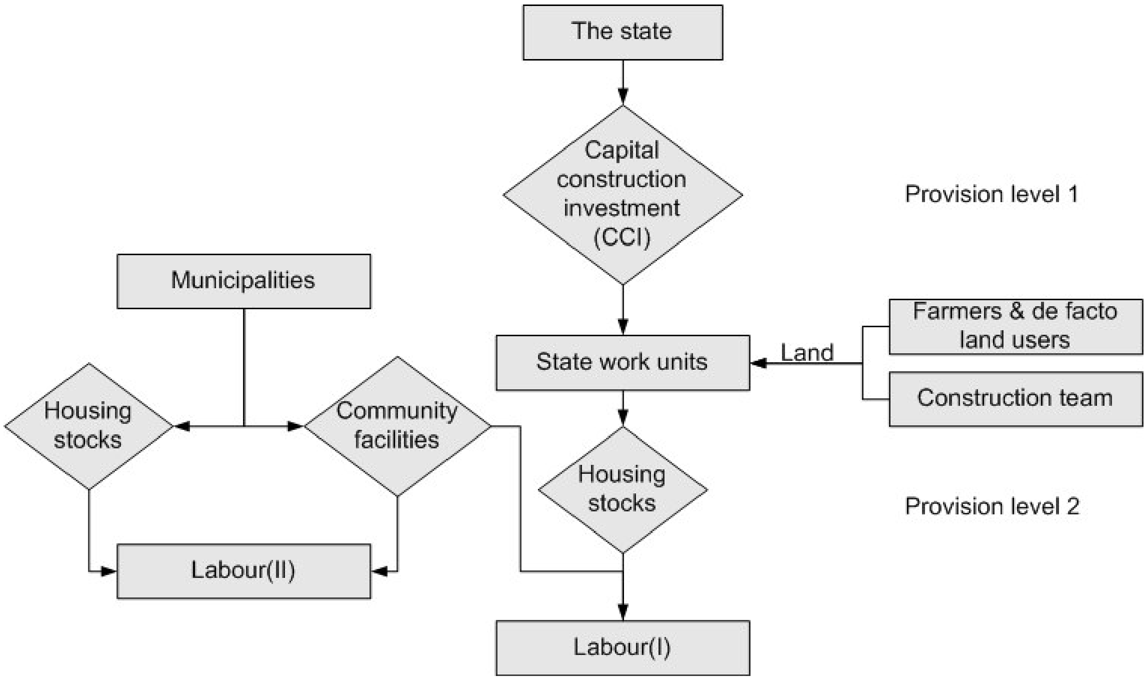

Figure 3-6: Traditional structure of public housing provision (Source from Ding (2002))

In Wuhan, the first public auction of the land use right for residential land parcel has taken place in March, 2001. Since that, most of land use rights began to be public auctioned at the market price. And residential land use right should be traded by public auctioned at the market which has been adopted in regulation of Wuhan city in 2002.

3.3.4.1. The role of government in land markets

Generally, there are three accepted justifications for government interventions into urban land markets:

- Elimination of market imperfections and failures to increase operating efficiencies;
- Removing externalities so that the social costs of land market outcomes correspond more closely to private costs; and
- To redistribute society's scarce resources so that disadvantaged groups can share in society's output.

Compared with land policy intervention in China land market, it can be summarized below:

- Incorporation of market mechanisms in the use of urban land (valuation and payment for land, secondary transactions in use rights by citizens and enterprises).
- Advancement of the rule of law by clarifying citizen and enterprise rights and the responsibilities and jurisdictions of government agencies, authorizing access to courts and mediating bodies, and strengthening criminal and civil sanctions.
- Enhancement of environmental protection and a balance in the use, development and preservation of land resources (sustainable development).
- Full preservation of cultivated land (no net loss), preservation and improvement of other agricultural land.

From above, the role of government in China is initial stage of land market development that first, it adopted market mechanisms in land market to regulated the valuation and payment for land; second the land market is transparent and competitive by law; third, it has responsible for the sustainable development by preservation of land resources. Meanwhile, the benchmark price has been used to guidelines of the land transaction in land market by land management department of municipality.

3.3.5. Current process of benchmark land price

Recently, the benchmark price of land value has been applied to land market in whole China. Depending on benchmark price, the land asset has been appraised for the land tax and land mortgage in bank etc. The main purpose of the benchmark price has been summarized as follows:

- To provide dependency through observation in tendency of land value in land market for making decision on the investment
- The dependency of land tax collection.
- Dependency on land auction, tender, and acquisition operation.
- To perform benchmark price appraisement and plot price announcement institution
- To provide the index about land price in Wuhan city for monitoring dynamic land price in Whole country.
- To guide land planning in short period.

The approach of the benchmark price valuation in Wuhan is mainly divided into the following 4 steps: step 1 is called expert grading process. In this method, the influence factors have been decided by multi-professional experts after panel discussion. Here, multi-professional experts are from census statistic bureau, transportation bureau, and environmental protection bureau, land planning departments. They give the weights for each factor; the average of weight has been calculated for measurement of land value. Step 2 is the classification of the whole urban area according to the condition of each aspect, such division and gradation is carried out separately by local special authorities, for example, the environmental protection bureau will take charge of grading the environment condition, and the transportation bureau will take charge of grading the transport condition, etc. Step 3 is dividing the physical homogeneous zone based on the each factor and the weight given to each aspect. Here, map overlay techniques are used. Each of these zones represents the general circumstance of certain territory. Step 4 is valuation of the average land value with different land use using existing land prices data. Depending on the report (Land and resources management of Wuhan city 2004), benchmark price for residential land use has been classified 6 classes, and it has been divided into zones. It is supposed that in certain physical homogeneous zone, the land values of the same land use are similar. The homogeneous area refers to areas with similar characteristics of the following 5 aspects: degree of prosperity, which actually is decided by the distance to the city centre and sub-centre (commercial density), communication condition, infrastructure and facility condition, environment quality, population status. They collect samples from housing transaction market, and housing rental service agency and land market, and the land values have been calculated from these samples. As to the residential land use benchmark price, as a long time, the transaction of the residential land takes place outside the land market, the samples prices of residential land use are very low and even have little difference between the transformations; its departure from the market makes it necessary that another substitute should be applicable. So the local authority use average house rent and house prices as an indicator to determine the value of residential land. Recently, the housing market develops fast, which makes that more data is becoming available on land prices for residential land use. The municipality of Wuhan intends to update the benchmark price annually and more efficiently.

4. Data preparation for model building

4.1. Introduction

The previous chapter gives a description of the study area. The present chapter is to prepare data for analyzing and describing the research methodology and details of the methods used in data collection, data measurement and data analysis needed to accomplish the research objectives. The statistical parameters used to analyze the data and to validate the model are also explained.

4.2. The research process

This research aims at determining the relative influence factors of independent variables on land market sale price (dependent variable) through the sale Comparison method and MRA calibrating. A dependent variable is regressed against a set of independent variables. It uses various parameters including coefficient of determination (R^2) and SEE, which will be explained later in the data analysis section of this chapter.

First, the dependent variable has been identified by literature review, the local knowledge from the interview with experts and the comparison of benchmark prices and market sale prices. From the previous analysis of the current process of benchmark price in Wuhan land market, it confirms that the benchmark price is accepted by the municipality of Wuhan, which be regarded as the guideline of the property tax, and reference of the land market price. Thus, the sale comparison method has been used to explain the market sale price compared with benchmark price; meanwhile, the real estate developer has some opinion about these sites. Through comparison, the additive influence factors have been found. The expert opinion also confirm on these factors. After determining the influence factors, the measurement of factors has been explained, and then the procedure of the model calibration and evaluation of MRA model will be presented in Chapter 5.
According to above discussion, the research process has been summarized in figure 4-1 below.

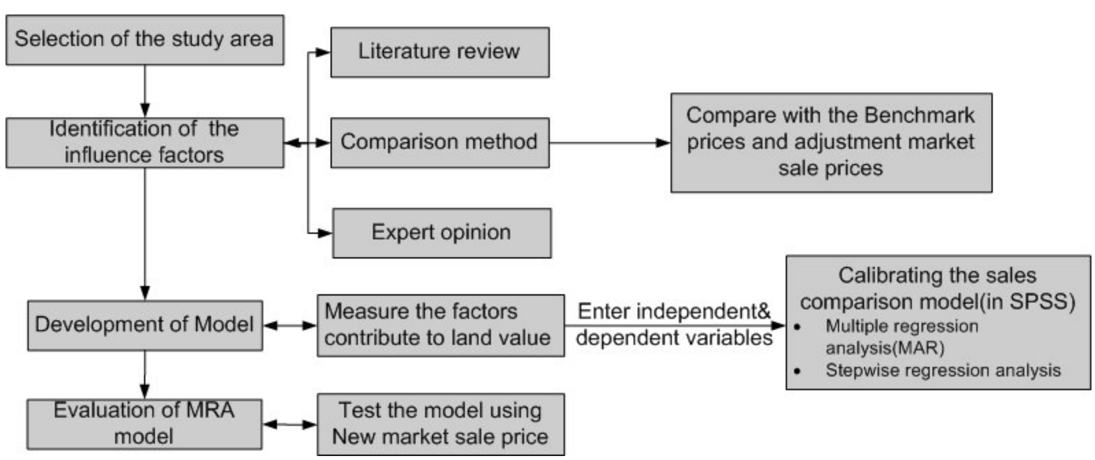

Figure 4-1: The research process

4.3. Data collection

In this research, a portion of the data set are collected from the land market centre of Wuhan municipality which includes five types of information: (1) transaction price, (2) details of the transacted property, including land area, street name, project (development) name and postal code, (3) floor area, floor area ratio, (4) land tenure of property and (5) contract and transfer dates of the transaction.

The contract date is the day when the property price is determined, which is appropriate for index property. The rest was thematic maps of the study area. The following are the departments approached from which data of various formats was collected:

- Urban planning and Design institution of Wuhan,
- Statistics bureau of Wuhan,
- Land & Resources department of the Hubei Province,
- Land valuation center of Wuhan city, and
- International Institute for Geo-information Science and Earth Observation, the Netherlands (ITC), etc.

In table 4-1, the data used in this research were categorized into two parts: spatial data and non-spatial data. The table also shows the types of the data that are relevant to the purpose of the research and the data format that was obtained.

Table 4-1: Data collection

Data description		Format
spatial	District, Town, and street boundary 2004	Digital map
	Distribution of the residential properties 2002 to 2004	Digital map
	Roads of the town in 2004	
	Land use 2004	Digital map
	Benchmark price 2004	Digital map
Non-spatial	Characteristics of the sample of the properties 2004	Investigation Document
	The registered land price (transaction price) 2001-2004	Document
	Reference land values 2004	Investigation
	Population density 2004	Document
	Report	Document
	Norms and regulations	Literature
	The policy about residential land planning 2004	Literature
	Land valuation model	Literature

The spatial data describe the spatial factors that have influence on residential land value and spatial data are mainly come from the digital maps provided by the urban planning bureau and theme maps provided by other government departments. The digital maps contain the most detailed information of all the objects above the ground (buildings, roads, land covers, etc).

The non-spatial data describe the market land price, the report of benchmark price in 2004 and the interview with expert about the residential land value in land market. The scale data for the sample of properties is obtained from the original record of the land transaction keeping in the local land market centre of municipality, which promises the data to be the primary data. Interviews with expert opinion for land values from both private and public sector gives witness in the selection of data, newspaper advertisements were also used as a reference in discussion with these experts. Data on land value was collected and entered as value per square meter in the local currency. Here, the expert opinion has been briefly described.

Expert opinion on the land market of Wuhan city

Expert Opinion is a relatively informal technique which can be used to serve a variety of purposes, and may be used to assist in problem identification, in clarifying the issues relevant to a particular topic, and in the evaluation of products. Individual experts can be consulted, but it is usually better to bring groups of experts together so that a wide range of experience can be drawn on. In addition, as far as the city land market is concerned, public opinion is another important source, always the most important one, to get an ideal tendency of land market in the future, which should be done through sampling inquiry. To gain an insight into the land market of Wuhan city, expert opinion and sampling inquiry about the factors contribute to the decision of potential house buyers were conducted, the sample size was 140. It was contacted in three districts of Hankou town, there were: 34 interviewee in Jiang'an, 30 interviewee in Qiaokou, and 76 interviewee in Jianghan. Contactee of experts came from private and public sectors; they are land estimators in land and resources management department of Hubei province and Wuhan municipality, and real estate developers. Here, the result has summarized as follows (table 4.2).

Table 4-2: Expert opinion and response of potential buyers in purchase of house in Hankou

Main factors		**Percentage of people interviewed (%)**			
		Very important	Important	Fairly important	Not important
Price		38.0	45.5	15.0	1.5
Location		30.0	52.0	14.5	3.5
Transportation		36.5	47.5	14.0	2.0
Up valuation		22.5	34.5	31.5	11.5
Environment	Natural environment	42.5	41.0	13.5	3.0
	Nearby amenities	37.0	48.0	13.5	1.5
	Educational environment	40.0	35.5	19.0	5.5
	Social environment	38.5	41.5	32.0	4.0
	Security environment	65.0	26.0	8.0	1.0
Building structure		18.5	56.0	22.0	3.0
Public service		38.5	50.5	8.5	2.0

As shown in the table, environmental factors, which include natural environment, nearby amenities, educational environment, social environment and security environment etc., play an important role in the decision of potential house buyers, especially the security environment, more than 91.0% interviewee think it is the major considerable factor to pick up a new house. Another significant factor to the house buyers is transportation; namely, not only the surround environment but also the access to some places, for instance, city center, school and working place etc. also play a positive role in the decision made. More over, as a developing country, price of the house is still an important factor and people prefer the economical house (fewer prices) due to the low salary level.

Market value is generally defined as the price a willing buyer would pay a willing seller for a property in its present condition with neither buyer nor seller under pressure to act. So the price of land is determined by the market forces of supply and demand. To determine an estimate of land market value, one should take the main factors explained above into account. Based on the present condition of Wuhan city and main objective of this research, some sub factors related to the main factors should be considered in the model (table 4-3).

Table 4-3: Factors contributed to the land value in the model

Main factors	Sub factors considerate in the model
Location	• Travel time to city centre • Access to sub-centre • Distance to hospital • Distance to post office • Distance to market (shopping) • Travel time to school
Transportation	• Access to main road • Access to public transportation
Environment	• Neighborhood quality • Influence by pollution industry • View of amenities • View of water • Influence of rail way

4.4. Data pre-processing

4.4.1. Sampling and analysis of land price

Empirical research usually base on partial information. To be able to make generalizations sample are used. The design and size of sample is crucial to get accurate estimates of the population from which the sample is taken. Researchers use a relatively small number of a sample as the basis for making inferences about all the cases. In this study, all the market transaction data of residential land use were selected because the total number of the land plots is 31 due to the shortage of previous cases; these residential properties were transacted in land market after 2001 when local land market bureau of Wuhan city was established. Fortunately, samples of properties covered the whole study area and distributed in each districts. The registered land price is the real market sale price, since it is available;

this sampling strategy ensured equal representation of the residential land plots. It is necessary to use sales for vacant plots to reflect the actual market and hence sample plots are vacant. Large variations were observed in land prices among the 21 neighbourhoods in Hankou town from 2002 to 2004 (appendix 9). For example, the variation of land prices in Houhu Township ranged from 2879 to 4401 Rmb. That means even in the same neighbourhood, there were varieties in land prices. As shown in appendix 3, land prices ranged from 972 Rmb to 12281 Rmb per square meters in 2004, it is vary in one zone and between zones. Indeed, land values were varied among the zone in the central town than in the other zones with respect to both the highest and the lowest land values according to the coefficients of variation (more detail analysis in section 4.4.2). In term of relationship between land price and distance to the city centre, as shown in figure 6-1 and figure 6-2, the highest values of land price is reached at 1.7 kilometres from city centre. Moreover, the distance to city centre could explain the residential land values variation; on the other side, the low price of land observed at city centre, and at far distance to city centre. It implies that the city centre has large land value variation. Moreover, the high average land price is near the city centre. In terms of the highest land values, the central town went higher than the non-central town.

4.4.2. Compare with the reference land value

The result of the analysis based on the sample survey shows the urban land value pattern of residential land use has taken place in land market. Since that the reference land value zone (the benchmark price), which is updated in 2004 and presented to public is the reference value of land price in Hankou land market. Thus, the comparison of actual prices of sample lands with the reference land value has been taken account in this research. As shown in appendix 8, the land prices are varies in one zone and between zones. Therefore, based on expert opinion, which was held during fieldwork with five experts from real estate development companies and the local land administration office, the variation of the land prices and the reference land value has been explained by experts' opinion. Some comparable attributes were determined from the comparison, contributed to land value. The explanation of the variation of the land prices in each zone has been taken as follows:

The map of the sample plots distribution in each land value zones (figure 4-2).

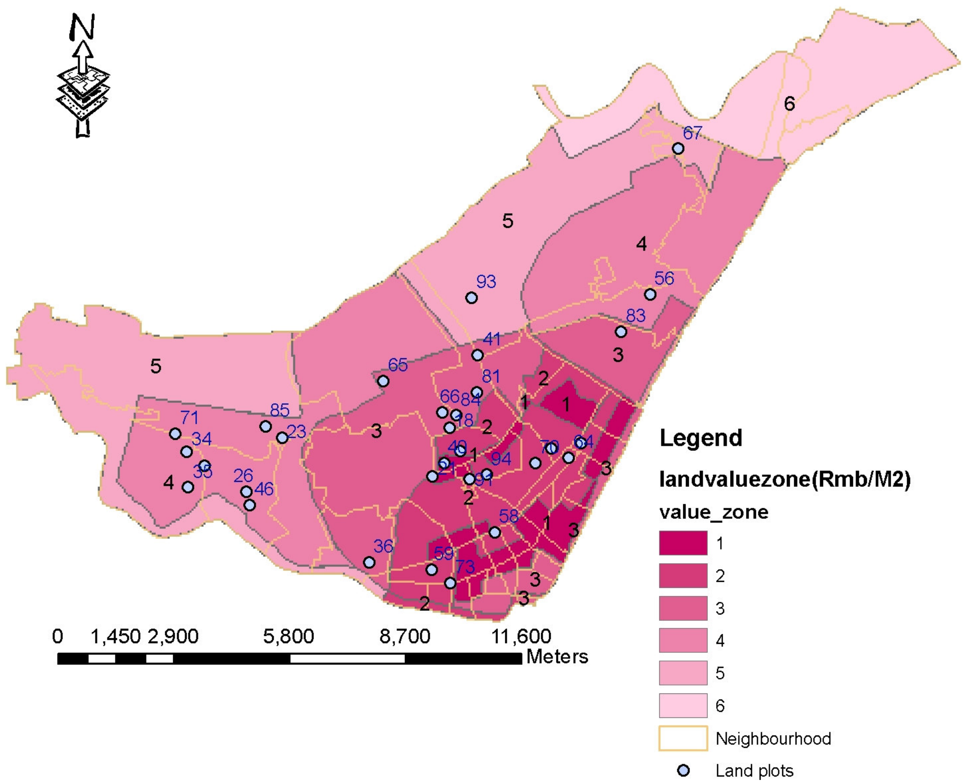

Figure 4-2: Distribution of sample plots in each reference land value zone

Compared with the reference land value, some land prices has been explained by experts; In zone 1, there was only one case (plot); this plot is situated at financial street of Beihu sub-centre, near Beihu Lake, the sale price is above benchmark price with 2.2 floor area ratio permitted.

In zone 2, there have 11 cases (plots) which occurred in land market. The general circumstance in this zone is better one, it is near to the city centre and has good environment, good quality infrastructures, etc, while almost land plots have achieved higher market price than the benchmark price. The highest price in this zone is plot No. 73 and 58, they are in different neighborhoods; both of the plots, have higher **FAR**, Plot No. 73, is situated in Hanzheng street, it is a historic wholesale business area with many private stores. The government wants to improve this area because it is the symbol of Wuhan traditional commercial centre. Meanwhile, the new policy of the river-side improvement has started; it has also improved the quality of neighborhood. So, real estate investors have been attracted to develop high quality of residential house. Another plot No. 58 is situated in the city centre, and **nearby the main road**. For these reasons, both of the plots got high prices in the land market. And the higher price in this zone, plot no 94 traded in 2004; the expert opinion of this plot has 3 points, firstly, its location which is near the main road, access to city centre and Beihu sub-centre; secondly, it is nearby amenities, access to Zhongshang Park; thirdly, it is good quality of neighborhood. In the same neighborhood and nearby plot No 94, there is another plot No 91 that also has high market price in the land market. But it is lower than plot No 94, because the construction permission is different. This implies that the higher the floor area ratio, the higher the price of the plot. Plot No 82, 59, 64, and 21 have also higher sale prices than the benchmark price. Plot No. 64 and 82 are located in different neighborhoods, but near each other. The main difference of these two plots is that the neighborhood of plot No 82 has a middle school, which is known for its good quality of education. Plot No 21 and 59 have similar sale price, and different location. The main characteristic is that one is near the financial street and the other is near the city centre.

In Zone 3, there are 8 cases (plots); all plots in the zone have a higher price than the benchmark price. The highest sale price of No 81 has taken place in 2004; another plot is also located in the same neighborhood, although has the same FAR as plot No 81, however shows a difference in prices up to 500 RMB/m^2; this is due to the fact that plot No 81 has 'water view', whereas plot No.84 does not have 'water view'. Plot No.18 is also near a water body (Lake of Beihu), and it has got higher sale price in this zone. And Plot No.66 is also in the same neighborhood as No18 which does not have a 'water view', so it has lower price as compared to plot No.18. Plot No. 83 is higher price than the benchmark price, because it is near a Park and near amenities compared with the same neighborhood plots.

In zone 4, there are 9 cases; most of them are lower price than benchmark price. Only two plots got high sale price compared with the benchmark price. Plot No.46 is near Han River, plot No.56 is along the main road.

In zone 5, there are only 2 cases (plots); one is higher price than the benchmark price; another is lower price than the benchmark price. The new residential land area has got the higher price of plots, and it will attract more migrant residents live in this neighborhood, which has planned land development and infrastructure will be developed by the government in the short period.

4.4.3. Influence factors of residential land value

In reality, the determination of an exact value for a land parcel is almost impossible but an estimation of the asset value can be conceivable. To estimate the value, some land valuation factors, which can affect the total perceived value of a land parcel, have been selected and spatially examined with the developed model. The list of considered land valuation factors from the comparison with benchmark price and expert opinion, the main influence factors can be decided. And these influence factors are both spatial and non-spatial fieldwork. In this part, the main independent variables will be described and measured. These are:

- Distance to city center and sub-centre,
- Distance to facilities i.e. post office, hospital, school, market
- Distance to pollution industry,
- Distance to main road,
- Distance to railway,
- Distance to amenity,
- Neighborhood quality (update to 2004),
- Number of bus-stop nearby,
- Near to water,
- The property characteristics i.e. land area, floor area ratio.

The following part, the measurements of each variable was explained.

4.5. Process of data preparation

4.5.1. Measuring accessibility

According to the three basic components of accessibility, people, activities and links, the corresponding data needed in this study are shown as figure 4-4. The appropriateness of various methods of measuring accessibility is shown below:

1. Distance decay can be excluded because in this case, i.e. the concept of travel impedance is declined because the amount of distance within 5000 meters has no impact on the attractiveness of the sub-centers.
2. Measures should be concerned with the need for the accessibility of origins (sample plots), so the short travel time from city center and school, the short travel distance from sub-center must be incorporate.
3. The road network reflects the cost of moving from one point to another. Delineation of a route and the cost of moving along this rout depend on the mode of transport. Hankou has a convenient public transportation system, taking bus is common in city, it means that traveling from city center and school considered as main transport mode for residents. For the dispersed business areas in the town, residents can reach nearby sub-center by walking.

According to the data requirement of measuring accessibility, three aspects data on origin, transport and destination are prepared for the following analysis. The relationship between the steps is portrayed in figure 4-4.

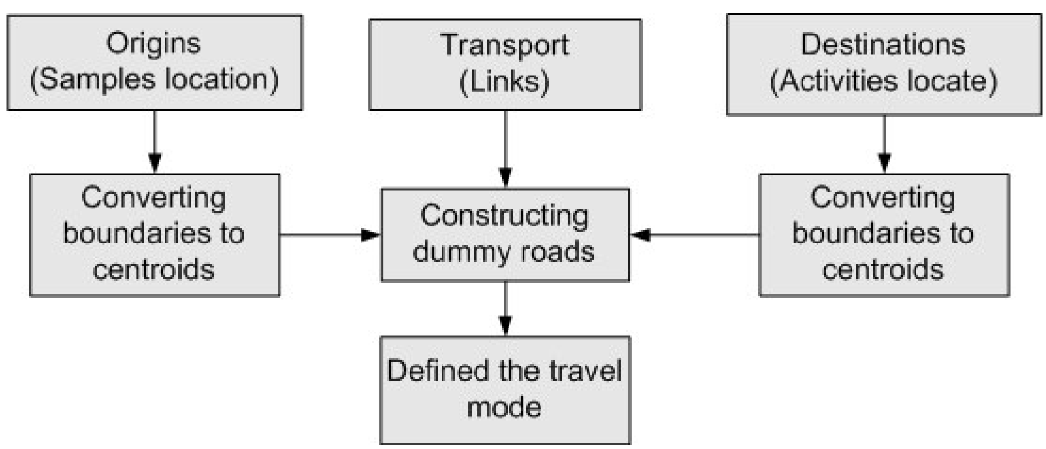

Figure 4-3: Process of data preparation for measuring accessibility

4.5.2. Measurement of the dependent variable

The actual market land price is defined as the dependent variable. Data on land price was collected and entered as value per square meter in the local currency (Chinese RMB per square meter). The residential plots are digitized in the ARCGIS software. According to the report of land market in Wuhan city, in 2004, the inflation of land value was 13.6% compared with last year (Land and resources management of Wuhan city 2004).

4.5.3. Measurement of the independent variables

The influence factors of the residential land value were determined through literature review and expert's opinion, comparison of the benchmark price. In this study, all of the factors have been measured or classified. However, the good model attributes to the accuracy measurement of the variables. Here, measuring the distance based on network distance (the technique of the accessibility measurement has been discussed before.) This sort of distance measurement is the most appropriate for our purpose for a more actual description of reality, based on this measurement of accessibility, the accuracy of the land value model will be improved. The classification criterion based on the report from local municipality, it is the benchmark land price valuation report, which has been adopted by local municipality.

4.5.3.1. Travel time to the city centre

Measuring the travel time from city centre has three processes. Firstly, the sample of land plots and the city center regarded as origin and destination points have been linked to the nearest node in road coverage with a search radius of 500 meters. Secondly, the speed of the bus and walking has been defined as 500 and 50 meters per minute respectively. Thirdly, the network distances between all the selected nodes in the network coverage by specifying a search radius, to limit how far to search around each node. Using the city center as the center, land plots' point as the stop for search and imp (time) as the impedance, in the output access table (appendix 7), an origin-destination table is constructed. The cost of traversing the shortest path along the road network between the two nodes is calculated. Thus, the accessibility to city center is shown below (figure 4-4). From this map, it shows the grade of the accessibility to city center, range from 3.8 minutes to 28 minutes.

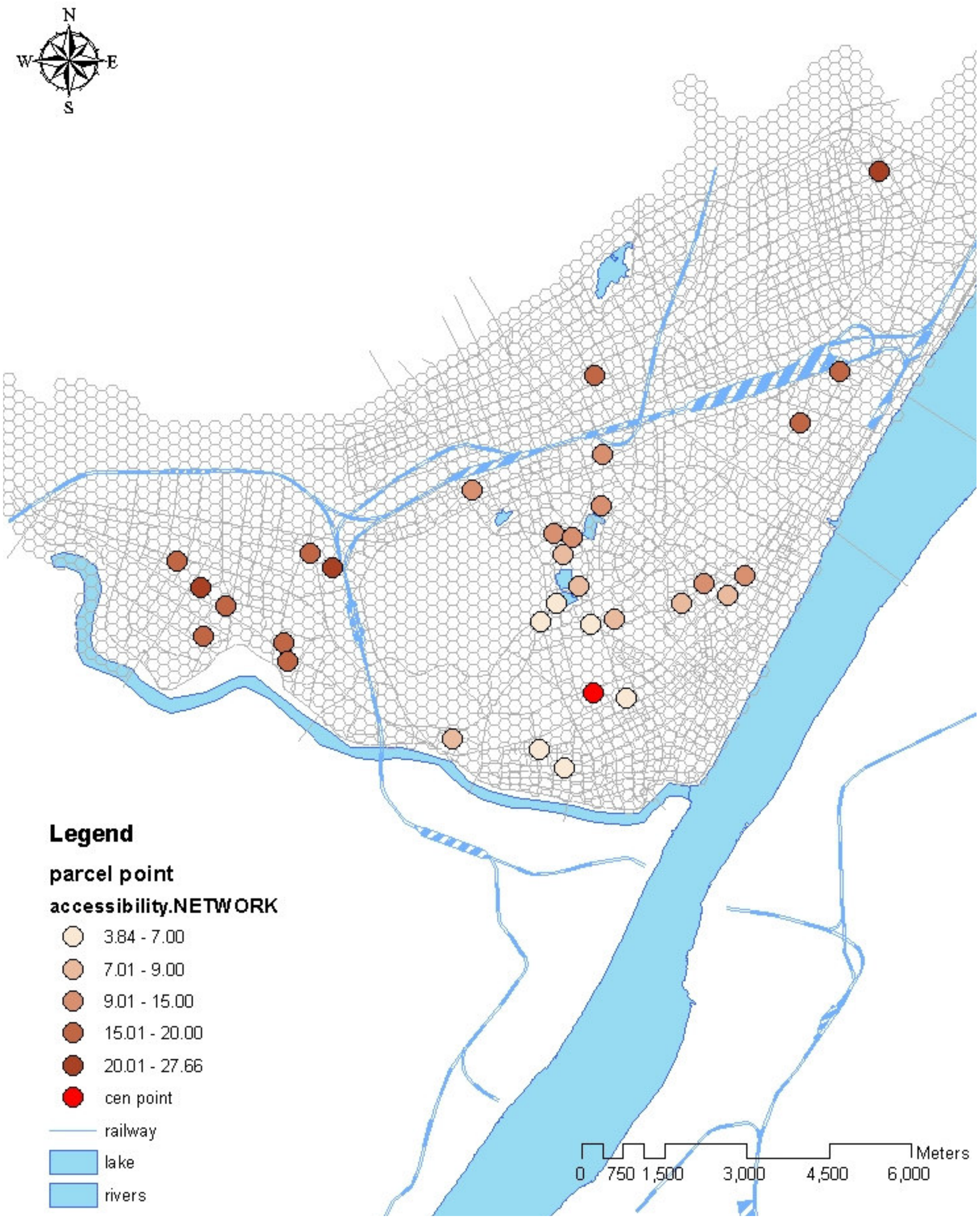

Figure 4-4: Accessibility to city center

4.5.3.2. Distance to sub-center

The same process as the measurement of accessibility to the city center has been used to measure the least distance to the subcentre. The destination point changed to the sub-center points; and the least distance to the subcentre has been calculated. As the output map shown below, the nearest distance from the sub-center is 253 meters and, the maximum distance is 4500 meters from sub-center. This node distance function was selected to measure accessibility to an urban sub-center. Nearness to an urban sub-centre is assumed to increase accessibility of household to jobs and to shopping facilities. Accessibility to an urban sub-center was measured as an actual network distances using ARCINFO (figure 4-5). The flowchart of the network analysis is in appendix 12.

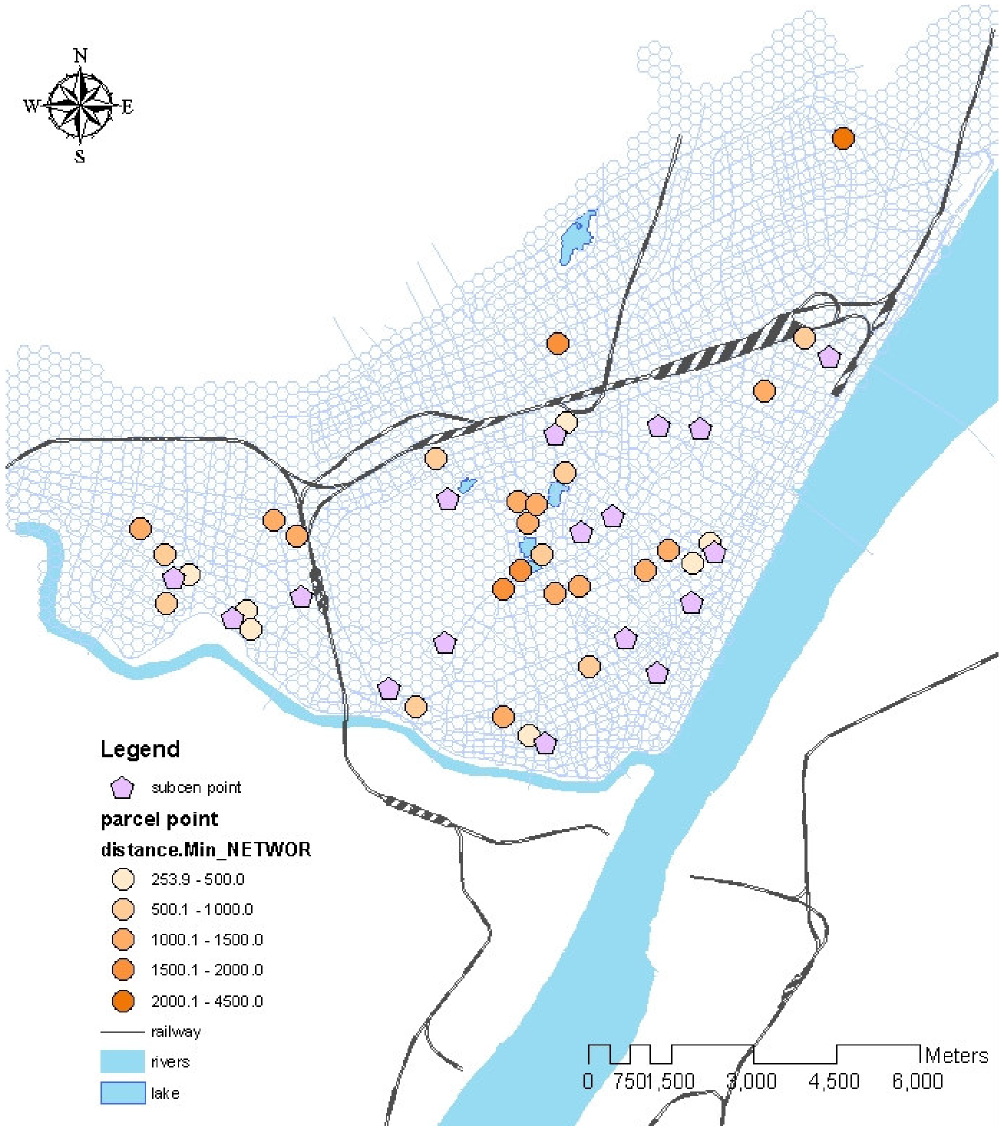

Figure 4-5: Distance to urban sub-center

4.5.3.3. Distance to school

The accessibility to school was considered. Since, the property which is near the good quality of school is favorable choice for the residential land development. Here, using same procedure as the measurement of accessibility to the city center, through node distance function in ARCINFO, only the destination points changed to the school points, the result was the least travel time to school. The least travel time to school of sample is ranged from 1min to 9 minutes.

4.5.3.4. Distance to hospital

This simple distance function was selected to measure accessibility to hospital. Nearness to a hospital is assumed to increase accessibility to treatment facility. The distance to hospital is range from inner 300 meters to inner 1500 meters. The definition of the criterion is referred to the report (Land and resources management of Wuhan city 2004).

4.5.3.5. Distance to other facilities

The influence of the public facilities is decided by the activity of the individuals and the families. Some of the activity should be considered in this case. Such as: distance to market, distance to post office, the simple distance function was selected to measure the accessibility to these facilities. These variables were measured as straight-line distance from the sample to nearest facilities. The values of these variables were the calculated distance to the aims places. The scale is meter. And the definition of the criteria is referred on the report (city 2004).

4.5.3.6. Neighborhood quality

The quality of life is more and more important in our society especially in urban area. As residential land use, quality will range from high class residential to a low class residential. Neighborhood quality was also observed in the field for sample of properties and measured in qualitative form. Each quality class was given a value between 50 and 100 (poor=50, fair=80, good=100). The nearness to local government or high popular institute, the crime rate, income level, population level were considered in deciding on the quality of neighborhood, the classification is referred to the report (Land and resources management of Wuhan city 2004).

4.5.3.7. Near water and amenities view

Water is the symbol of the treasure in China. Since the land plot is near water body, the real estate investors has been attracted to develop residential house, and the residents are also prefer to live around water, an ideal measure of the land value should take account of this attribute. In this research, some samples are near water. Others are not availability of water within view of property. This binary dummy variable is given the value of 1; otherwise the value is 0. And another favorable attribute includes access to amenity place. For a property that possesses the characteristics of an amenity view, in this case, the measure was based on the distance. The dummy variable takes on the value of 100 if the distance to amenity is less than 300 meters; 80 if the distance to amenities is more than 300 meters but less than 500 meters; and 50 if the distance to amenity is more than 500 meters.

4.5.3.8. Noise level and pollution level

The negative attributes are near the railway or heavy and middle pollution industry (Land and resources management of Wuhan city 2004). The land plot which near the railway has an influence by the noise, this dummy variable takes on the value of 1 if the distance to railway is less than 400 meters from property; and 0 if the distance to railway is more than 400 meters. Pollution level is valued by the distance to heavy pollution industry and middle pollution industry. The simple distance function was used to measure it. While the land plot is near pollution source, it means that the land plot has bad environment. Values for this variable were between from 50 to 100 (high pollution= 50, middle pollution=80, no pollution=100). The measure criteria are referred to the report..

4.5.3.9. Distance to main road and bus-stop

Accessibility to the main road is attached high value by household in locating where to live. Meanwhile, most of bus stops are located along the main road. Hence, it is assumed that land values increase with nearness to the main road. This variable was measured as straight-line distance from the sample of properties to the nearest main road. The value of this variable is ranged from 50 to 100 (near the main road=100, near the second road=80, near the branch road=50). The number of bus-stop near the sample of properties also was account for the land price. Values for this variable were between from 1 to 3 (the convenient location to transport facility=1, the less convenient location to transport facility=2, inconvenient location to the transport facility=3).

4.6. Development of the model

4.6.1. Using GIS in data process

After the process of data measurement, the model has been developed. Before construct the land valuation model, selection of the appropriate technique to display the data which ensure valuations cost effective and easy to understand has been considered. In the recent past, Wyatt (1995) asserted that GIS provides a technological platform on which to base such an analysis and an initial stage is the spatial representation of property information in the form of value maps (Yomralioglu and Nisanci 2004). GIS capabilities not only facilitate the organization and management of geographic data, but they also enable researchers to take full advantage of location information contained in these databases to support the application of spatial statistical and spatial econometric tools (Can 1998). Due to the complexity of land valuation process, providing property owners with an easy understood explanation of how their property has been valued is a continual challenge for planners and assessors. According on the required data for land valuation analysis, they are derived from the plots, zoning, thematic, and topographical maps. Land plots values are determined by the combination of mathematical analysis and subjective judgment (figure 4-3). All the maps were generalized, related to one land use only and a specific point in time. The functionality of a GIS means that a value map need not be a static display but can form part of a more analytical process. It citied by Nisanci in 2004, problems in the past related to a lack of staff resources, the production of expensive paper maps and the complex calculations involved. In this research, land value maps display, data input and calculations of the results all realized in GIS.

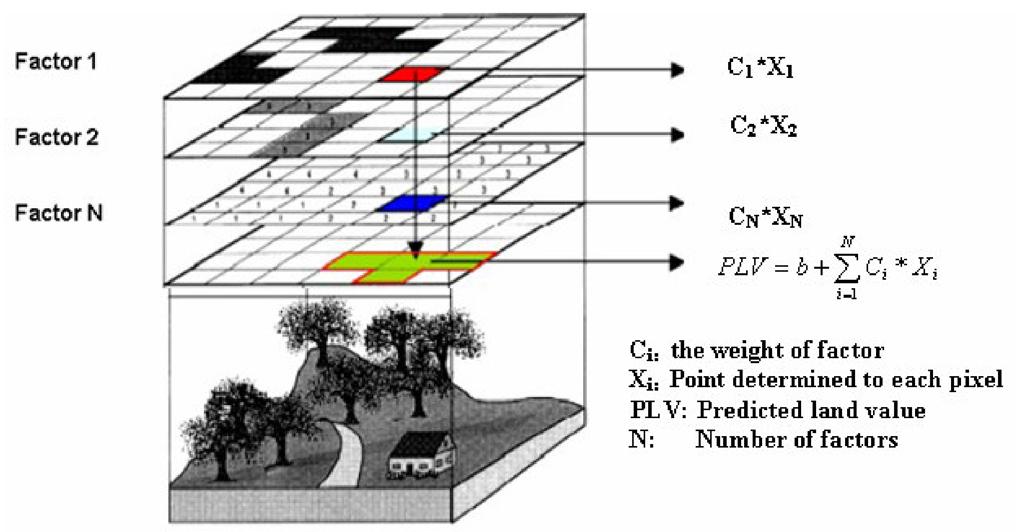

Figure 4-6: Calculation of a land value on a pixel-base
(Source from Yomralioglu and Nisanci (2004))

4.6.2. Variables and multiple regression equation

The major concern in model estimation is to identify those variables that explain the significant variation in land prices base on the transaction-based land prices. These variables will then be regressed on the dependent variable. As explained previous, influence factors that can potentially explain the structure of land value changes were selected based on literature review, local knowledge of the experts, and comparison process. A hedonic regression is used to estimate a land price equation for residential land use. The land valuation model can be formulated as follows:

$$\begin{aligned} RMLV = {} & b + C_1 ARA + C_2 FAR + C_3 NEQ + C_4 SCH + C_5 POL + C_6 AME + C_7 HOP + C_8 POS \\ & + C_9 NEW + C_{10} NER + C_{11} MAK + C_{12} MAR + C_{13} BUS + C_{14} ACC + C_{15} ACS \end{aligned}$$

Where, b is the constant and C_1 to C_{15} are the value rating for the independent variables.

RMLV is the value of the residential land per square meter at location I, with characteristic.
ARA is the registered land area
FAR is the permitted floor area ratio in regulation
NEQ is the neighborhood quality
SCH is the travel time to near school
HOP is the distance to hospital
POS is the distance to post office
POL is the influence by pollution industry
AME is the view of amenity
NEW is the view of water
NERI is the influence of rail way
MAK is the access to market (shopping)
MAR is the access to main road
BUS is the access to public transportation
ACC is the travel time to city centre
ACS is the access to sub-center

The database construction has been installed in SPSS (appendix 11).

4.6.3. Evaluating and interpreting multiple regression model

In previous chapter, the techniques of evaluating the accuracy of the models have been introduced. According to the previous research, the main criteria in designing valuation models are below.

Firstly, the land value model should be understandable and explainable. The coefficients in the model should be consistent with appraisal theory and combined with the local situation. Secondly, the model should predict land values as close as possible the market prices. However, it should be noted that the accuracy of the model depends on both the variables included in the model replicating market value, and the market data used for calibrating the model. The former has been validated in this chapter. The new market data used for calibrating is from registered plots in land market recently. Thirdly, the model should be acceptable to both the public and valuation estimators. This factor actually depends on the performance of the model in predicting values as has been pointed above. This should be evaluated after the model has been implemented.

Last but not least, the goodness of fit of the model should be valuated by some statistical tests. Therefore, different measures are used to evaluate the predictive accuracy of the models and to show the importance of individual variables in the methods, have been explained below:

Coefficient of determination (R^2)

This is the proportion of variation in land value explained by the regression model. The values of R^2 range from 0 to 1. Small values indicate that the model does not fit the data well. On the other side, when R^2 equals 1, all variations in values are explained by the regression equation. If R^2 equals 1 in a one variable model, it means if value is plotted against the variable, all values would lie on a straight line. The coefficient of determination, R^2, based on this relationship, is computed as

$$R^2 = \frac{\sum (\hat{S}_i - \bar{S})^2}{\sum (S_i - \bar{S})^2}$$

Where S_i is the sale price of property i, $\hat{S}_i$ is the estimated price, $\bar{S}$ is the average sale price, i=1… n (where n is the number of sales)

Unstandardized coefficients (B)

The unstandardized coefficients are the coefficients of the estimated regression model, which tell how much the dependent variable changes in response to a one unit change in the independent variable.

Standardized coefficients (Beta)

These are obtained by transforming the dependent and independent variables so that they have means of zero and standard deviations of one. For each variable, this is accomplished by subtracting its mean and dividing by its standard deviation. Beta measures the percentage change in a land value associated with a percentage change in an independent variable with all other factors held constant. Betas are an attempt to make the regression coefficients more comparable.

T-statistic

This is a measure of the significance or importance of a regression variable in explaining differences in the dependent variable (land price). When t is large, one can be confident that the variable is significant in the prediction of land price. Conversely, when t is small, one cannot reject the hypothesis that standard error equals 0 and that variable is unimportant in explaining land price. It should be emphasized, however, that this does not mean that variable is not correlated with land price. The t-value measures the marginal contribution of a variable in predicting land price when all other variables included in the equation are held constant. Because some variables duplicate information provided by others, they may be highly correlated with land price, but insignificant predictors as indicated by their t-values. Conversely, other variables possess the peculiarity of predicting land prices in combination, although individually none may be highly correlated with land prices. It is calculated as the ratio of the regression coefficient. In general, provided that sample size is large (at least fifty), a t-statistic in excess of ±2 indicates that one can be 95 percent confident and the variable is significant in predicting land price.

F-Statistic

The F-Statistic is related to the t-statistic and is also used to test whether or not individual regression variables are significant in predicting the dependent variable, land price. In general, an F-statistic of 4.0 or larger indicates that a variable is significant in predicting land price at the 95 percent confidence level, provided that sample size is large.

Standard error of the estimate (SEE)

The standard error of the estimate measures the amount of deviation between actual and predicted land prices. Note that whereas R^2 is a percentage figure, the SEE is in money figure, in other words, whereas R^2 evaluates the seriousness of the errors indirectly by comparing them with the variation of the land prices, the SEE evaluates them directly in money terms. Thus, the lower the SEE, the more reliable the model is (Eckert 1990).

5. Development and testing of land valuation model

5.1. Introduction

In this chapter the market sale price of land based on each proposed influence factors in terms of variables are analyzed to check the pattern of value. Statistical analysis techniques are used to test the significance of individual variables. Data measurement procedures were explained in previous chapter. This chapter concentrates only on residential land valuation model development and testing. The evaluation of the multilevel variables will be described which are related to the market sale price. The ARCGIS 8.3 and SPSS software package will be used for data analysis and model calibration.

5.2. Data availability

According to the analysis in chapter 4, the main influence factors of residential land value have been decided. The table below shows the variables used in this model.

Table 5-1: List of variables and their definitions

Code	Variables (expected sign)	Definition of variables
AJP	Adjusted price	Price in RMB/M^2
ARA	Total land area (-)	Gross land area in M^2
FAR	Floor area ratio (+)	Floor area ratio
NEQ	Neighbourhood quality (+)	100 if it is suitable population density and located local government and famous institute; 80 if it is less suitable and few institute located in there; 50 otherwise
POL	Pollution source (-)	50 if it is near the pollution source search radius 300 meters; 80 if it is 500 meters away from pollution source;100 otherwise
AME	Amenities view (+)	100 if it is near the amenity place, search radius 300 meters; 80 if it is available to the amenity place, search radius 500 meters; 50 otherwise
HOP	Accessibility of hospital (+)	Distance to the nearest hospital from site of property
POS	Accessibility of post office (+)	Distance to the nearest post office from site of property
NEW	Near water body (+)	1 if availability of water within view of property, 0 otherwise
NER	Distance to railway (-)	1 if it is near railway and has noise pollution by train, 0 otherwise
SCH	Accessibility of school (+)	Travel time to school from site of property.
MAK	Accessibility of market (+)	Distance to the nearest market from site of property
MAR	Near main road (+)	100 if it is near main road; 80 if it is near second road; 50 if it is near branch road
BUS	Convenient transportation (+)	1 if it is convenient to public transportation.; 2 if it is less convenient to public transportation; 3 otherwise
ACC	Accessibility of city centre (+)	Travel time to city centre from site of property
ACS	Accessibility of sub centre (+)	Distance to sub centre from site of property.

5.3. Data Analysis

The land valuation is an estimate or an opinion of value of an adequately described property as of a specified date, supported by the presentation and analysis of relevant data. Since the research is intended to test whether the variables from multilevel factors are significant to determine the value of property, statistic analysis is considered as a potentially useful tool to fulfill this intention. To assess the significance of each independent variable, two approaches to analyze the data have been used.

5.3.1. Descriptive statistic

Descriptive statistic is the first step to explore and understand the data set. The objective of this step is to summarize statistically the principal characteristics of relevant distribution, to make it simple to explain and to aid comparison with other distribution. In the research, the market sale price of each property was analyzed to measure dispersion based on each influence factors. Measures of dispersion show the dissimilarity of the values; these include standard error, variance, standard deviation, minimum, maximum, range.

The completeness of the data set was confirmed by the descriptive statistics shown in table 5-2, 5-3 and figure 5-1. The first approach is to confirm the reasonableness of these descriptive statistics. The results indicate that the market sale prices are high variance. As shown in figure 5-1, it is not normal distribution. The means and standard deviations of each variable were checked. The mean of a binary variable indicates the percentage of parcels possessing that characteristic. From the table 5-3, 26% properties are near water; 13% properties are influence by noise of railway.

Table 5-2: Descriptive statistics for the dependent variable

N	Valid	31
	Missing	0
Mean		4238.7525
Median		4188.4300
Mode		6377.40
Std. Deviation		2791.80331
Variance		7794165.728
Skewness		.899
Std. Error of Skewness		.421
Kurtosis		.781
Std. Error of Kurtosis		.821
Range		11308.87

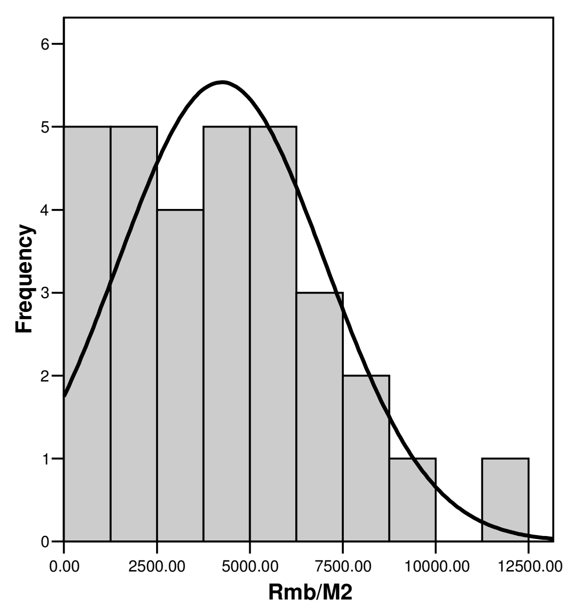

Figure 5-1: Histogram of dependent variable distribution

Table 5-3: Descriptive statistics for the independent variables

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
area	31	310730	1113	311844	38818.88	64054.533	4102983204.908
FAR	31	4.32	1.18	5.50	2.7281	1.15252	1.328
NEQ	31	50	50	100	80.32	16.017	256.559
POL	31	50	50	100	97.74	9.560	91.398
AME	31	50	50	100	77.74	22.317	498.065
HOP	31	900	300	1200	735.48	329.189	108365.591
POS	31	1300	300	1600	1100.00	503.322	253333.333
NEW	31	1	0	1	.26	.445	.198
NERI	31	1	0	1	.13	.341	.116
SCH	31	8.35	.61	8.96	5.0932	2.11265	4.463
MAK	31	700	300	1000	564.52	293.880	86365.591
MAR	31	50	50	100	60.32	18.526	343.226
BUS	31	2	1	3	2.10	.539	.290
ACC	31	23.82	3.84	27.66	12.8835	6.05745	36.693
ACS	31	4195.00	254.00	4449.00	1071.2258	757.38069	573625.514
Valid N (listwise)	31						

5.3.2. Correlation matrix

It is described by Blalock in 1979 (citied by (Somwung 2001)) that, When interest is focused primarily on the exploratory task of finding out which variables are related to a given variable, we are likely to be mainly interested in measures of degree of relationship such as correlation coefficient. Correlation summarizes the strength of relationship between two variables, but it is important to remember that correlation is not causation (D.G 1991). Several different correlation coefficients can be calculated, but the two most commonly used are Pearson's correlation coefficients and Spearman's rank correlation coefficients. Pearson's correlation coefficients require both variables to be measured on an interval or ratio scale and the calculation is based on the actual values. Spearman's rank coefficients require data that are at least ordinal and the calculation, which is the same as for Pearson correlation, is carried out on the ranks of the data. Each variable is ranked separately by putting the values of the variable in order and numbering them: for example, the lowest value is given rank 1, the next lowest is given rank 2 and so on. If two data values for the variable are the same they are given averaged ranks, so if they would have been ranked 14 and 15 then they both receive rank 14.5. Based on the attributes of the data, the Spearman's rank correlation coefficient was used as a measure of linear relationship with the variables.

The table 5-4 shows the correlation matrix for the 15 independent variables and the dependent variable based on the plots. The matrix of variables indicates a rank-order correlation coefficient which measures association at the ordinal level. This is a nonparametric version of the Spearman’s correlation based on the ranks of the data rather than the actual values. The values of the correlation coefficient range from -1 to 1. The sign of the correlation coefficient indicates the direction of the relationship (positive or negative). The absolute value of the correlation coefficient indicates the strength, with larger absolute values indicating stronger relationships. The correlation coefficients on the main diagonal are always 1.0; because each variable has a perfect positive linear relationship with itself. A correlation close to 0 indicates that the two variables are not related at all. A positive R implies that when one variable increases, the other variable increases while a negative R implies that when one variable increases, the other decreases. This is an indication that there is a strong explanatory interrelationship between the variables, which can lead to multicollinearity. This term is used to describe the combined influence of a number of independent variables where the influence of each is difficult to isolate. Multicollinearity occurs where the independent variables are highly correlated. From the table 5-4, the independent variables of AME and NEQ, ACC and FAR, the correlations are high level with one another. Whilst, the independent variables of FAR, NEQ, AME ACC are correlated highly with AJU, other variables show moderate or weak correlation with one another. However, the correlation coefficient is a dimensionless percentage, indicating only whether two variables are linearly related.

Table 5-4: Correlation matrix of variables

	AJU	ARA	FAR	NEQ	POL	HOP	AME	POS	NEW	NERI	SCH	MAK	MAR	BUS	ACC	ACS
AJU	1.000	-.340(*)	.911(**)	.705(**)	.398(*)	-.224	.737(**)	.003	.375(*)	-.237	-.498(**)	-.466(**)	.448(**)	-.399(*)	-.830(**)	.073
ARA		1.000	-.281	-.276	.096	-.241	-.326(*)	-.055	.041	-.032	.305(*)	.204	-.215	-.063	.440(**)	-.375(*)
FAR			1.000	.545(**)	.352(*)	-.310(*)	.621(**)	-.120	.272	-.248	-.582(**)	-.522(**)	.422(**)	-.473(**)	-.789(**)	.001
NEQ				1.000	.246	-.248	.737(**)	-.024	.251	-.073	-.366(*)	-.220	.249	-.317(*)	-.639(**)	.125
POL					1.000	.074	.314(*)	-.263	.155	.101	-.111	-.268	-.193	-.460(**)	-.312(*)	-.369(*)
HOP						1.000	-.125	.124	.072	.126	.322(*)	.230	-.231	.237	.119	.167
AME							1.000	.076	.459(**)	-.254	-.318(*)	-.408(*)	.267	-.426(**)	-.602(**)	.333(*)
POS								1.000	.135	-.255	-.126	-.148	.260	.097	-.074	.443(**)
NEW									1.000	-.227	-.272	-.337(*)	.365(*)	-.253	-.379(*)	.058
NERI										1.000	.124	.160	-.224	.128	.301(*)	-.226
SCH											1.000	.462(**)	-.422(**)	.270	.551(**)	-.014
MAK												1.000	-.157	.555(**)	.492(**)	.149
MAR													1.000	-.072	-.255	.199
BUS														1.000	.376(*)	.454(**)
ACC															1.000	-.044
ACS																1.000

* Correlation is significant at the 0.05 level (1-tailed).
** Correlation is significant at the 0.01 level (1-tailed).

5.3.3. The linear relationship of land prices and variables

As has been known from earlier work, the land prices have explained by accessibility to the city center, committed with accessibility increases dramatically with increasing land price levels (correlation =-0.833). Table 5-5 shows such data for thirty-one recently sold lands for residential land use. These data are graphed and a straight line fitted to the points with a ruler, as was done to generate line in Figure 5-2. The sale price of an unsold land for residential land use can be estimated by noting its accessibility to city centre and reading the corresponding estimated adjusted sale price.

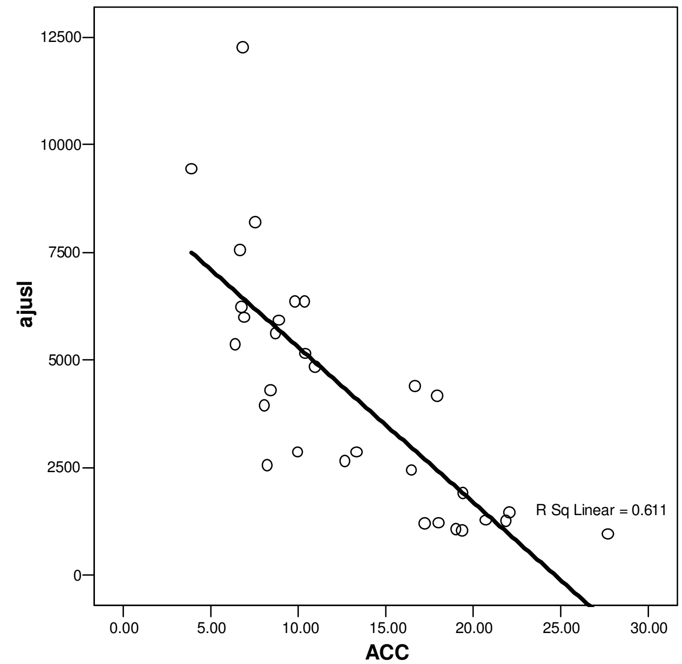

Figure 5-2: Scatter diagram of land price to accessibility to city center

Table 5-5: Regression data

No	Price (Rmb/M^2)	Travel time (minutes)		No	Price (Rmb/M^2)	Travel time (minutes)
1	9453	3.84		17	4854	10.92
2	5377	6.32		18	2668	12.62
3	7566	6.62		19	2879	13.26
4	6256	6.67		20	2457	16.42
5	12281	6.78		21	4401	16.61
6	6001	6.84		22	1213	17.15
7	8220	7.46		23	4188	17.88
8	3958	7.99		24	1233	17.96
9	2576	8.16		25	1092	18.96
10	4320	8.35		26	1063	19.32
11	5635	8.63		27	1929	19.37
12	5942	8.81		28	1304	20.65
13	6377	9.76		29	1293	21.81
14	2878	9.91		30	1474	22.02
15	6377	10.3		31	972	27.66
16	5164	10.34				

Another independent variable, which has been regarded as important influence factor of the land value according on literature review, as shown in figure 5-3, there is virtually no relationship between distance to subcentre and land value, making it impossible to draw the line of best fit. In recent past, some studies have used a distance decay function to investigate further as distance from a subcentre varies, the expanded regression model should be follow the regression analysis. Here, modelling the subcentre influence at different spatial levels hasn't expanded. Furthermore, the parameter estimates of proximity to the subcentre by use of distance intervals, is important in the next step of analysis.

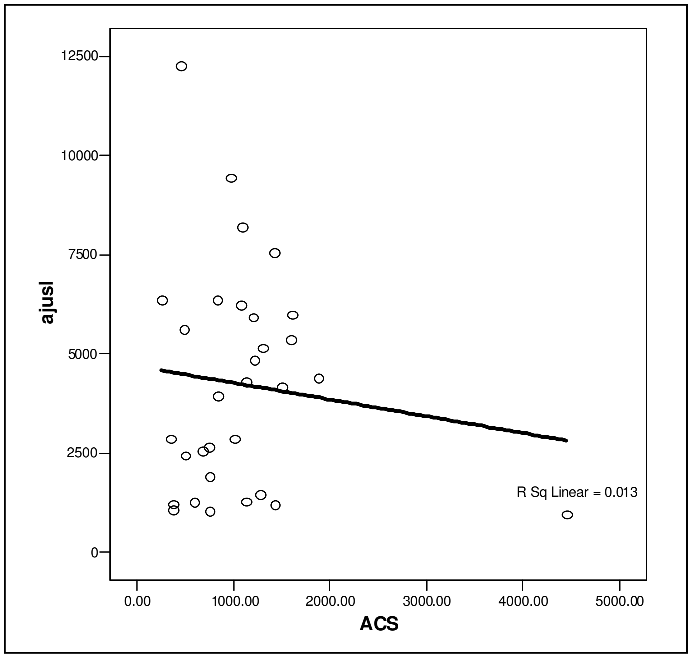

Figure 5-3: Scatter diagram of land price to distance from subcenter

5.4. The empirical result

According to the correlation matrix, the variables are not correlated highly; so the nonlinear regression method has been used to find a nonlinear model of the relationship between the dependent variable and a set of independent variables. Unlike traditional linear regression, which is restricted to estimating linear models, nonlinear regression can estimate models with arbitrary relationships between independent and dependent variables. This is accomplished using iterative estimation algorithms. Note that this procedure is not necessary for simple polynomial models of the form Y = A + BX**2. By defining W = X**2, we get a simple linear model, Y = A + BW, which can be estimated using traditional methods such as the Linear Regression procedure. In this case, the dependent variable of land values and the independent variables of ARA and POST were transformed into common logarithms. Furthermore, at this step, a stepwise regression building approach was used, which starts by including all the independent variables and then discarding those that do not have a significant role in determining land values. Therefore, only variables that are significant in explaining variations in the dependent variable are included. In this case, a variable is entered into the model if the significance level of its F value is less than the Entry value 0.3. Test of the hedonic regression model (1 to 10) are shown in table 5-5. All the variables except SCH, NER, BUS, ACS, HOP, and MAR are significant. The explanatory powers of the models are close to 95 percent of the variation in (log) land values. Note that the explanatory power of the regression equation without the location variables (e.g. using only the ARA, FAR) decreases to 79.6 percent (see model 2). The coefficient associated with floor area ratio is highly significant, indicating that the floor area ratio has a strong and positive influence on land values (see model 1). It is interesting to note that the positive effect of NEW indicates that land buyers strongly favor water view plots (see model 5). The variable accessibility to the city center also has a strong and positive influence on land values (see model 4). Below an in the order of their significance, several models are summarized as:

Table 5-6: Model summary for MAR

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.879(a)	.773	.765	.15531
2	.892(j)	.796	.782	.14964
3	.948(b)	.899	.891	.10564
4	.965(c)	.932	.925	.08804
5	.969(d)	.939	.930	.08470
6	.972(e)	.944	.933	.08292
7	.973(f)	.947	.934	.08246
8	.974(g)	.950	.934	.08217
9	.976(h)	.953	.936	.08126
10	.979(i)	.957	.939	.07897

5.4.1. Model 1 (FAR)

At the first step, the variable floor area ratio (FAR) enters the equation. The results show that FAR is the most dominant variable determining land prices. Individually, FAR had an intercept constant of 2.857 and a positive coefficient of 0.244. Thus the relationship between log of land value and FAR independently of other variables can be given as:

LOG (Predict land values) = 2.857 + 0.244 FAR

From the table 5-5, the adjusted R^2 is 0.765 means that this model build with FAR only, can account for 76.5 percent of the total land value variations. e.g. the other factors account for 23.5 percent of the land value variations. Here, R^2 is the coefficient of determination and is the percentage of the variance in land prices explained by the model. Adjusted R squared attempts to correct R squared to more closely reflect the goodness of fit of the model.

5.4.2. Model 2 (FAR and AME)

The second variable to enter the equation is amenity view (AME). This is the second most important variable in explaining land value variations. The adjusted R squared in this model is 0.891 means that the two variables account for 89.1 percent of the land value variations. Entry of amenity view into the model increased R2 by 12.6 percent. The regression is now modeled as follows:

LOG (Predict land values) = 2.561 +0.179*FAR +0.006 * AME

5.4.3. Model 3 (FAR, AME and ACC)

The accessibility to city center is the third variable to enter the equation and its explanatory power of the regression equation increases to 92.5 percent that means the entry of ACC in the model increases R^2 by 3.4 percent. The regression model is now enlarged to:

LOG (predict land values) = 2.941 + 0 .144 FAR + 0.005 AME - 0.014 ACC

5.4.4. Model 9 (FAR, AME, ACC, NEW, MAK, ARA, POL, POS and NEQ)

The finial model, the explanatory power of the regression equation increases to 93.9 percent, and the last variable to enter the equation is NEQ. Entry of NEQ in the model increases R^2 by 0.3percent, and the SEE decreases to 0.07897. The finial model can be written as:

LOG (predict land values) = 2.178 + 0.165 FAR +0.003 AME -0.007ACC +0.082 NEW+ 0.163Log (MAK)–0.059Log (ARA) +0.004POL–0.0051POS+0.003NEQ

Tests of the model 9 are shown in the table 5-5 and 5-6. All the variables are significant. As expected, the coefficient on ARA is negative, large area of plots is generally perceived to have lower prices per unit; the coefficient on POL is positive, the plots which are near pollution area are perceived to have lower prices per unit than plots that no pollution influenced (the weight of no pollution is 100, see table 5-1). The coefficient on POS indicates that the increased distance to the post office will decrease the land values. And the effect of neighborhood quality is also remarkable; the coefficient on NEQ is positive, high neighborhood quality increase proportionately with its land value. Since the view of water is attractive in Wuhan, the demand for view water plots is relatively greater in such neighborhood plots. It is interesting to note that the positive effect of market (Log (MAK)) indicates that the far from market led to the higher land unit prices. However, through this stepwise regression analysis, the other factors measured were insignificant in explaining variations and hence were excluded from the finial model.

Table 5-7: Model coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.857	0.073		39.312	0
	FAR	0.244	0.025	0.879	9.935	0
2	(Constant)	2.561	0.071		36.278	0
	FAR	0.179	0.02	0.646	8.954	0
	AME	0.006	0.001	0.425	5.889	0
3	(Constant)	2.941	0.12		24.588	0
	FAR	0.144	0.019	0.519	7.474	0
	AME	0.005	0.001	0.336	5.182	0
	ACC	-0.014	0.004	-0.264	-3.649	0.001
4	(Constant)	2.754	0.156		17.702	0
	FAR	0.146	0.019	0.526	7.864	0
	AME	0.004	0.001	0.266	3.606	0.001
	ACC	-0.011	0.004	-0.209	-2.748	0.011
	NEQ	0.003	0.002	0.137	1.781	0.087
5	(Constant)	2.759	0.152		18.108	0
	FAR	0.147	0.018	0.529	8.067	0
	AME	0.003	0.001	0.223	2.854	0.009
	ACC	-0.011	0.004	-0.202	-2.702	0.012
	NEQ	0.003	0.002	0.151	1.986	0.058
	NEW	0.057	0.039	0.078	1.459	0.157
6	(Constant)	2.901	0.197		14.744	0
	FAR	0.148	0.018	0.531	8.145	0
	AME	0.003	0.001	0.2	2.49	0.02
	ACC	-0.01	0.004	-0.191	-2.548	0.018
	NEQ	0.003	0.002	0.157	2.07	0.049
	NEW	0.063	0.039	0.087	1.616	0.119
	logARA	-0.033	0.029	-0.058	-1.131	0.269
7	(Constant)	2.675	0.286		9.349	0
	FAR	0.154	0.019	0.553	8.126	0
	AME	0.003	0.001	0.214	2.639	0.015
	ACC	-0.011	0.004	-0.205	-2.706	0.013
	NEQ	0.003	0.002	0.138	1.77	0.09
	NEW	0.07	0.039	0.098	1.788	0.087
	logARA	-0.036	0.029	-0.064	-1.252	0.223
	LOGMAK	0.092	0.085	0.064	1.081	0.291
8	(Constant)	2.415	0.353		6.838	0
	FAR	0.158	0.019	0.569	8.299	0
	AME	0.003	0.001	0.202	2.5	0.02
	ACC	-0.008	0.004	-0.159	-1.89	0.072
	NEQ	0.003	0.002	0.139	1.806	0.085
	NEW	0.076	0.039	0.105	1.927	0.067
	logARA	-0.052	0.031	-0.092	-1.663	0.11
	LOGMAK	0.111	0.085	0.077	1.296	0.208
	POL	0.002	0.002	0.074	1.233	0.231
9	(Constant)	2.178	0.377		5.773	0
	FAR	0.165	0.019	0.595	8.651	0
	AME	0.003	0.001	0.198	2.527	0.02
	ACC	-0.007	0.004	-0.135	-1.618	0.121
	NEQ	0.003	0.002	0.151	2.011	0.057
	NEW	0.082	0.038	0.113	2.133	0.045
	logARA	-0.059	0.031	-0.105	-1.922	0.068
	LOGMAK	0.163	0.09	0.114	1.813	0.084
	POL	0.003	0.002	0.102	1.663	0.111
	POS	-0.0051	0.034	-0.077	-1.514	0.145

Notes that the variables “SCH, NER, BUS, ACS, HOP, and MAR” were excluded from all models, the regression was run with the all variables using the enter option. Adjusted R2 decreased to 91.7 percent and the SEE increases to 0.09242. This means these variables were insignificant in explaining land value variation, thus these variables excluded from the model. However, excluded factors have the important influence with the land value based on the local knowledge from experts and interviewee, especially school, it has regarded as the main element for the buyer. Since some factors have relevant with it. For example, neighbourhood’s quality has been classified, based on many criteria include the condition of education, that the neighbourhoods quality has included in the model without the variable of school.

5.5. Evaluating model

The validity and interpretation of the multiple regression models depend on the extent to which certain assumptions are met. The most important in the context of models are complete and accurate data, linearity, additivity, normally distributed errors, constant variance of the errors, uncorrelated independent variables, and sample representativeness (Eckert 1990).

First assumption, Compete and accurate data have been verified previous (chapter 4). **The second assumption** means that the marginal contribution to land value of an independent variable is constant over the entire range of the variable. For example, for the variable floor area ratio, linearity requires each unit of floor area ratio to add equally to land value. Because the linearity assumption often cannot be supported, it may be necessary to transform the data used in additive models through various mathematical manipulations; for example, taking the logarithm of square feet of land area may produce an approximately linear relationship. **The assumption 3** was confirmed that there is no multicollinearity as it was found that there are no two independent variables that are highly correlated. **The assumption 4** was checked whether the regression residuals are normally distributed with a mean of zero. Residual here means the difference between the actual value of the dependent variable and the values of the dependent variable estimated by the regression model. Figure 5-4 shows that the regression standardized residuals for my model obey this rule, mean is close to zero.

The assumption 5 implies that the residuals are uncorrelated with the dependent variable, land prices. Violation of this assumption, known as hereroscedasticity suggests that higher-priced properties tend to sell over a broader range than lower-priced properties. This situation causes concern because the regression model will be unduly influenced by the high-value properties and, thus, be less reliable when applied to low value properties. Multiplicative model avoids the problem by taking the natural logarithm of the dependent variable, which usually produces a sufficiently normal distribution. In this case, the dependent variable has taken the natural logarithm. Meanwhile, the test of using the new data set from the land market recently has been processed in the model.

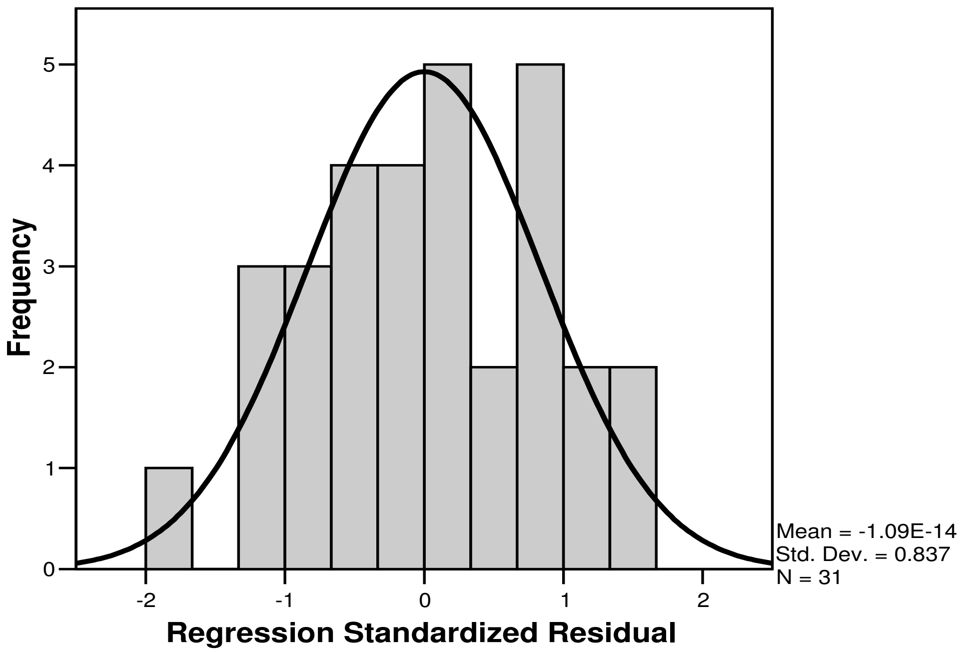

Figure 5-4: Histogram of regression standardized residual of the model 9

The assumption 6 was checked the multicollinearity of the independent variables. It is crucial, however, to distinguish two types of multicollinearity: perfect and imperfect. Perfect multicollinearity exists when there is a linear relationship between two or more variables. This means that one of the variables can always be expressed as a constant multiple of the other or others. For example, two variables, a and b, would be perfectly collinear if an equals 1.5b for all values of a and b. imperfect multicollinearity occurs when certain of the independent variables are correlated but there are no exact linear relationships. The simple procedure to reduce multicollinearity is to eliminate redundant variables. When two variables are highly correlated, one can often be excluded from the model with little loss in predictive accuracy. The other variable should have a reasonable coefficient, its standard error should fall, and its t- or F-value should increase. To a large extent, stepwise regression performs this process automatically by excluding variables that fail to meet a specified significance level.
The assumption 7 was representativeness of samples. Comparing descriptive statistics (such as means and standard deviations), frequency distributions are one means of monitoring representativeness. This process has been explained in previous.

Of the above assumptions, the most important relate to **complete, accurate, and representative data.** Land valuation model tends to work well even when the other assumptions are violated. Except that serious violations can cause unreliable models.

Using new data set test

Using new data set from the land market transaction data to test the model, the data set is provided by municipality recently. The comparison with the land sale price, predict prices and benchmark price has been explained below (table: 5-8).

Table 5-8: The comparison with 3 types of prices

Notes: Difference value = Predict land values (the benchmark price) - Land prices;
Deviation Percentage = Difference value / Land prices*100

Predict land values (Rmb/M^2)	Land prices (Rmb/M^2)	Benchmark price (Rmb/M^2)	Deviation Percentage (%)	Deviation Percentage (%)
3654	3596	4398	22.3	1.6
3847	4404	2330	-47.1	-12.6
7692	8223	4398	-46.5	-6.5
1668	1600	1731	8.2	4.3
4909	4614	2330	-49.5	6.4
2512	2830	1731	-38.8	-11.2

From the table, it shows that the predict prices from my model are close to land sale prices and more perfect than benchmark price. Although, some of the deviation percentages are lower, the least one is only 1.6 percent; Then, some of the predict prices deviate with land sale prices obviously; one of deviation percentages is up to 12.6 percent. Hence, I have briefly explained for this land plot and its predicted price. The plot is situated in zone 3, which the benchmark price is 2330; the location of the plot is far away from city center (see: appendix 10, the travel time to city center is 16.17 minutes), whereas it is located at the main road through the second bridge and connected with Wuchang town (figure 5-3).

Figure 5-5: Location of the sample

From the neighborhood quality side, this plot is also close to high-grade education of second school and next to the Jiefang Park. The plot of sale price achieved much higher price than the benchmark price. Meanwhile, there haven't comparable lands applied to the model construction. Since that the model can not accurately predict unique plots price. And notes that some of the influence factors has omitted, which are relevant with land value strongly.

5.6. Conclusion

The results presented above have documented the important of the accessibility to city centre, floor area ratio and neighbourhood amenities in hedonic analysis of land market. Under the estimations obtained above, the model can be understandable and explainable. Since the limited land transaction records of residential land use in Land market, and land market has operated in Wuhan only for several years, since that my model is not perfect that can predict accurate land value in land market from year to year. It confirmed that the accuracy, complete, and representative data is the most important to construct the land valuation model.

6. Conclusion and recommendation

6.1. Main conclusions

In this research, effort was focused on applying GIS and SPSS to model the residential land value. The research questions include the following main aspects:

1. What are the spatial patterns of land values in Hankou town?
2. How to design an approach to model the residential land values appropriate for Hankou town?
3. How well does the model agree with actual land values in Hankou town?

In the following section in this chapter, some findings and problems encountered in this research will be discussed and then the conclusion of this research will be given based on the result of this research.

6.1.1. The spatial patterns of land values in Hankou town

Rapid urban development and globalization have brought dynamic changes to large cities in the developing countries. Yet understanding of the changes has been impeded by the lack of data and systematic attempts. Urban planners and policy-makers regard land valuation as a guideline of the property tax and valuing the land market price. So that they suggest that the comprehensive of the spatial pattern of land values is a long period and continual challenge for planners and assessors.

From previous researches, the main influence factors of the residential land value can be divided into three aspects, i.e., physical characteristics, location characteristics and temporal characteristics; and both measurable variables and non-measurable variables. Thus, selecting the significant factors, which can comparable with the market sale prices, is very important to model the residential land value.

In this research, the influence factors are selected were as follows based on knowledge of literature, local knowledge of experts and the benchmark price report: travel time to city center, distance to sub-center, neighborhood quality, access to main road, water view, access to amenity, pollution level, noise level, travel time to school, distance to school, distance to post office, distance to market, convenient of the public transportation stop, land area, and floor area ratio.

By using the data from actual transactions in Hankou, this paper provides insights into the spatial structure of land values in Hankou town. It was found that Land values do vary drastically within one land value zone and between zones, with most of the expensive land parcels in central town. However, in city center few of land parcels were developed in recent years. The more lands have been developed near the city center with high market prices (figure 6-1). But one could also easily find cheap land parcels whose values were lower than the land values of some parcels in non-central regions of the town, reflecting the variation in property values in central town (figure 6-2). Land values were not distributed evenly in the non-central regions. Rather, they were more expensive in north and south-east town than in west Hankou (appendix 9). Spatial variables, especially distance to the city center, were important in shaping land value patterns in Hankou. The findings of this paper will not only be useful for an understanding of spatial land value patterns in Wuhan city, but will also be beneficial for investors and policy-makers in their decision-making processes.

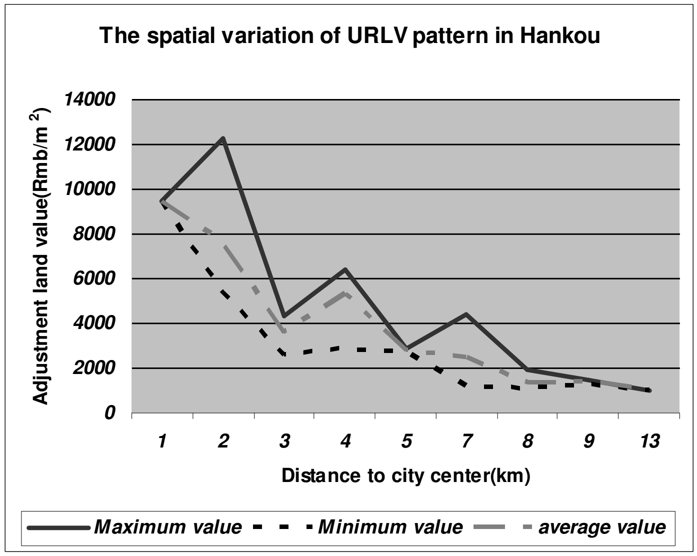

Figure 6-1: The spatial variation of URLV in Hankou (data from 2002 to 2004)

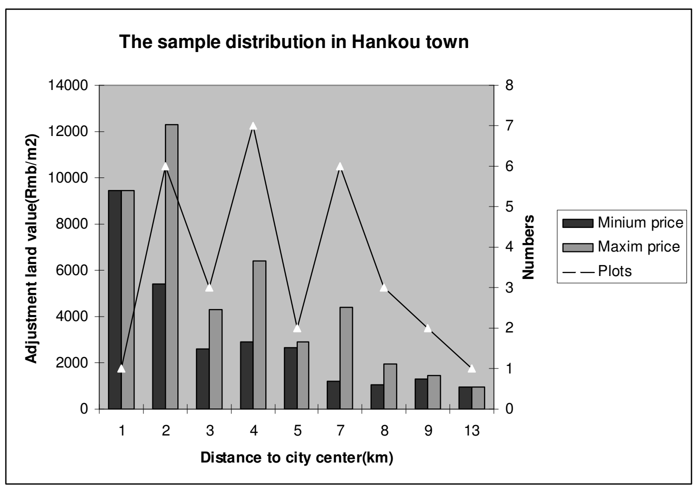

Figure 6-2: Transaction cases in Hankou town from 2002 to 2004

6.1.2. Approach to model residential land values

After determining the influence factors, the multiple regression analysis has been used to calibrate the model of residential land value. However, as the data of variables was not normally distributed from the descriptive statistic of the variables and nonparametric correlation matrix of variables; thus, the nonlinear regression has been used to estimate the model. Using a stepwise regression approach, the significant influence factors automatically have been included, and demonstrate that increases in land prices are strongly related to these influence factors of the residential land value, e.g. FAR, AME, ACC, NEW, MAK, ARA, POL, POS and NEQ, based on the sample of residential land use in land market of Wuhan from 2002 to 2004. In addition, the outline of the spatial data measurement using

GIS technique has been demonstrated in chapter 4, which enabled this task to be accomplished using multiple regression analysis function. For the location is a frequent explanation of land values, the accurate measure of the accessibility has important influence of the result, so that the main accessibility methods have been discussed, and the contour measure of accessibility has applied to measure the travel time to city center and school, and distance to subcenter.

6.1.3. Appropriateness of the model

By using stepwise regression analysis, it was shown that the main spatial factors shaping land values in Hankou town were travel time to city center, good quality of environment and neighborhood. The distance to the city center, which showed an inverse relationship with land value, was a dominant factor in explaining land value variations. Nearness to amenity was a significant variable in all nine models, demonstrating a positive relationship with residential land value. The neighborhood had a direct relationship with residential land value. Housing provision was dominated by the welfare housing system before 1998; since the land market was immature that the systematic analysis the land value couldn't be done. Consequently, the local government has lost revenue by low land price and low property tax. Furthermore, the benchmark price has been proclaimed from 1999 and update in 2001, and 2004. It has not been systematically adjusted until now. Thus, this research has provided a feasible approach to automatically update the land valuation model based on the transactions-based data from recent transaction. As the result, the model is tested by the new data set; it can predict the land price within 12 percent deviation. For the land valuation system in Wuhan, the accuracy and systematical land valuation system can save money and directly control the land price lost.

6.1.4. Limitations

The lack of a large, complete, accurate, and representative data set is one of the major limitations for this model. From the test of new data set, it shows the land price is also influence by the subcenter and new planning development. In stepwise approach, it excludes the influence factors which have significant correlation with the land value, but the sample is not perfect and representative. That is why these main factors were not included in my model.

And a time limitation is another important reason, Hankou town is part of the Wuhan city, and it is commercial central of the city. However, the other two towns also have their function in the city; it couldn't neglect their influence in land value. The finding shows that the land plot that near Wuchang town has higher land price than the plot nears the city centre. Thus, the model is not perfect based on the sample in Hankou town.

6.2. Recomendation

From above discussion, the recommendations for further are:
Systematically and regularly adjusted the land value should be taken into account when carrying out the benchmark price to ensure effectively labor and material, and provide the guideline for the land planning and making decision. Moreover, it is not too much to say that the first requirement of a good land valuation is that it has economic importance: that both owners and those who take part in making the valuation were associated in the work and with sufficient interest. But it also goes without saying that these greater demands for efficiency. For good land valuation authorities, it should be equipped with the information and the technical aids that are essential for doing the work of valuation well.

More accurate data and information is needed for land valuation. The land value has dynamic characteristic. So that comprehensive the land value variation should not only from spatial characteristics but also from temporal characteristics. Thus, the completion of the accurate land market prices registration and renewal should be recorded year after year. And the theme maps should be collected and update in the land information database. Based on these data and information, the land valuation authorities could deeply analyzes the dynamic land value variation in Wuhan. And understanding the hinder influence factors of land value and improve the land management system and land planning.

Technique improvement should be taken into account. In this research, applying GIS and SPSS has improved the accuracy of the measurement and efficiently accomplished land valuation. So it couldn't neglect the new technology efficiency in land valuation. Moreover, GIS capabilities not only facilitate the organization and management of geographic data, but they also enable researchers to take full advantage of location information contained in these databases to support the application of spatial statistical and spatial econometric tools (Can 1998). Due to the complexity of land valuation process, providing property owners with an easy understood explanation of how their property has been valued is a continual challenge for planners and assessors.

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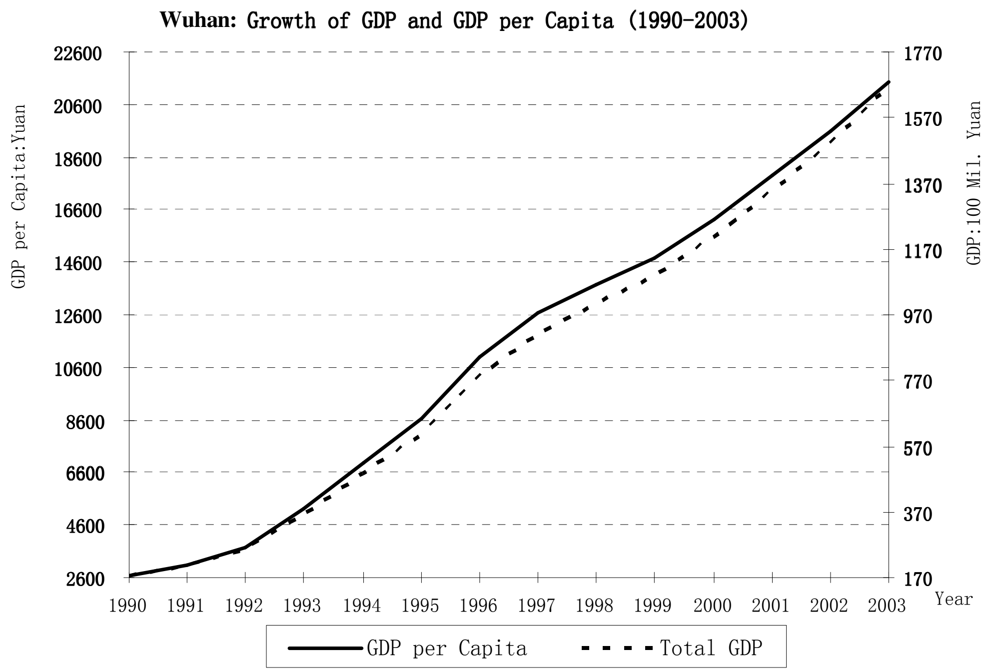
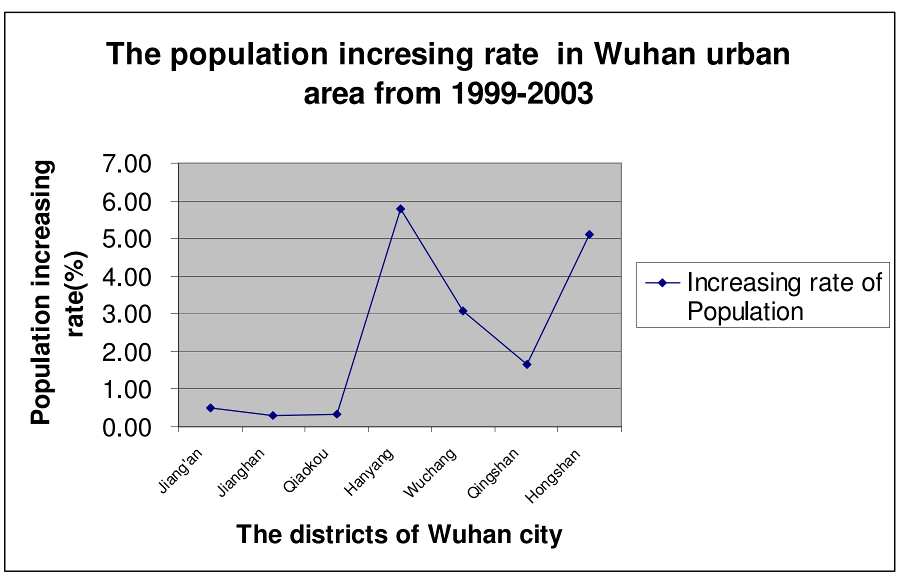
Appendices

Appendix 1: Growth of GDP AND GDP per capita (1990-2003)
(Source from Wuhan yearbook 2004)



Appendix 2: The population increasing rate in Wuhan, district level (1999-2003)
(Source from: Wuhan yearbook 2004)



Appendix 3: Land right transaction by auction and bid after 2001

No.	Area (m^2)	Auction year	Land price (Rmb/m^2)	FAR	Benchmark price
17	21693	2002	3112	2.21	3221
18	14227	2002	4671	3.02	2330
20	6101	2002	2263	2.95	3221
21	3817	2002	4718	4.45	3221
23	46420	2002	1025	1.18	1731
26	73263	2002	970	1.50	1731
27	141858	2002	858	1.57	1731
34	17521	2002	1016	1.59	1731
35	142536	2003	936	1.57	1731
36	2276	2003	2268	1.62	2330
40	2896	2003	4733	2.31	4398
41	7344	2003	2534	2.20	2330
46	76477	2003	2163	1.80	1731
56	13612	2003	1698	1.76	1731
58	12035	2003	8322	4.10	3221
59	7740	2003	5507	4.5	2330
64	112950	2003	4960	4.00	3221
65	10941	2003	2349	2.80	2330
66	11270	2003	4546	3.50	2330
67	4444	2003	856	1.50	1268
70	10585	2004	4320	3.00	3221
71	49536	2004	1474	1.44	1731
73	16880	2004	12281	5.50	3221
81	11782	2004	6377	3.80	2330
82	16769	2004	6377	3.50	2330
83	311844	2004	4188	2.5	2330
84	21630	2004	4854	3.80	2330
85	19879	2004	1213	1.50	1731
91	7147	2004	7566	3.20	3221
93	1113	2004	4401	2.1	1268
94	6800	2004	8220	4.1	3221

Appendix 4: New data set of land transaction in Land market

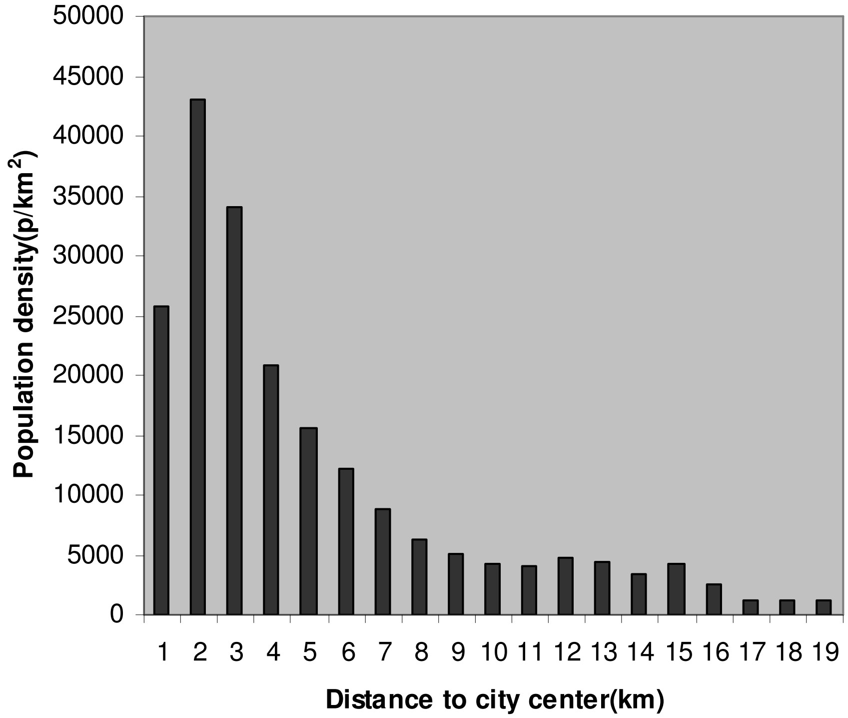
No.	Area (m^2)	Land location	Land price (Rmb/m^2)	FAR	Benchmark price
1	20300	Jiang'an,shengli street	3596	3.5	4398
2	1112.57	Jiang'an, huangpu street,Luojia zhuang	4404	1.6	2330
3	6809.76	Jiang'an, Daibei 1 road	8223	4.0	4398
4	58620.39	Qiaokou, Jianyi 126road	1600	1.6	1731
5	39679.55	Qiaokou, Baofeng road	4614	4.0	2330
6	315234.2	Jiang'an chama road	2830	2.19	1731

Appendix 5: The table of classes of neighbourhood quality

Neighborhood	Population	Area	Density
Low density or high income areas			
Kan_jia_ji_town	687	6957827.37	99
Hou_hu_township	19457	28846509.87	675
Chang_feng_township	23946	22019098.00	1088
Wan_song_street	13193	8225394.00	1604
Jiang_han_township	21959	11453820.00	1917
Dan_shui_chi_street	37539	6581146.87	5704
Yi_jia_dun_street	64432	7965582.50	8089
Dai_shan_street	10274	994605.75	10330
Xin_hua_street	20616	1512044.63	13635
Hua_qiao_street	45065	2056496.87	21913
Tai_bei_street	26784	861032.93	31107
Xi_ma_street	50735	1490035.25	34050
Yong_qing_street	31092	839542.56	37034
Bei_hu_street	23934	1663188.50	14390
Medium density or middle income areas			
Han_jia_dun_street	49519	3890133.75	12729
Zong_guan_street	47956	3440295.50	13940
Dai_jia_shan_str	23237	1608466.75	14447
Xin_cun_street	53866	3533074.12	15246
Tang_jia_dun_street	66586	4035544.25	16500
Er_qi_street	75829	4190573.37	18095

Han_shui_street	50454	2782045.00	18136
Lao_dong_street	63452	2824488.62	22465
Tong_yi_street	15857	628473.75	25231
Bao_feng_street	51397	1832459.00	28048
Qian_jin_street	22991	725412.81	31694
Min_quan_street	23031	706301.81	32608
Yi_yuan_street	23435	717677.00	32654
Hua_lou_street	25206	751466.56	33542
Man_chun_street	24711	729725.69	33863
Wang_jia_xiang_stree	18672	505859.52	36911
Min_yi_street	31634	842388.44	37553
Min_zu_street	34510	918021.41	37592
Han_zheng_street	35006	914507.00	38279
Si_wei_street	29024	755947.00	38394
Shang_hai_street	35815	849203.62	42175
Liu_jiao_ting_street	38283	738271.19	51855
Rong_hua_street	44300	829693.81	53393
Han_zhong_street	23448	414187.22	56612
Bao_qing_street	36057	631258.69	57119
Li_ji_street	25541	442205.19	57758
High density or low income areas			
Che_zhan_street	30042	351301.97	85516
San_shu_street	23163	245143.16	94488
Qiu_chang_street	39537	418255.50	94528
Xin_an_street	24733	249701.20	99050
Da_zhi_street	36995	367131.03	100768
Shui_ta_street	119403	733935.09	162689

Appendix 6: Population density in the build-up areas of Hankou town



Appendix 7: Access table of travel time to City centre

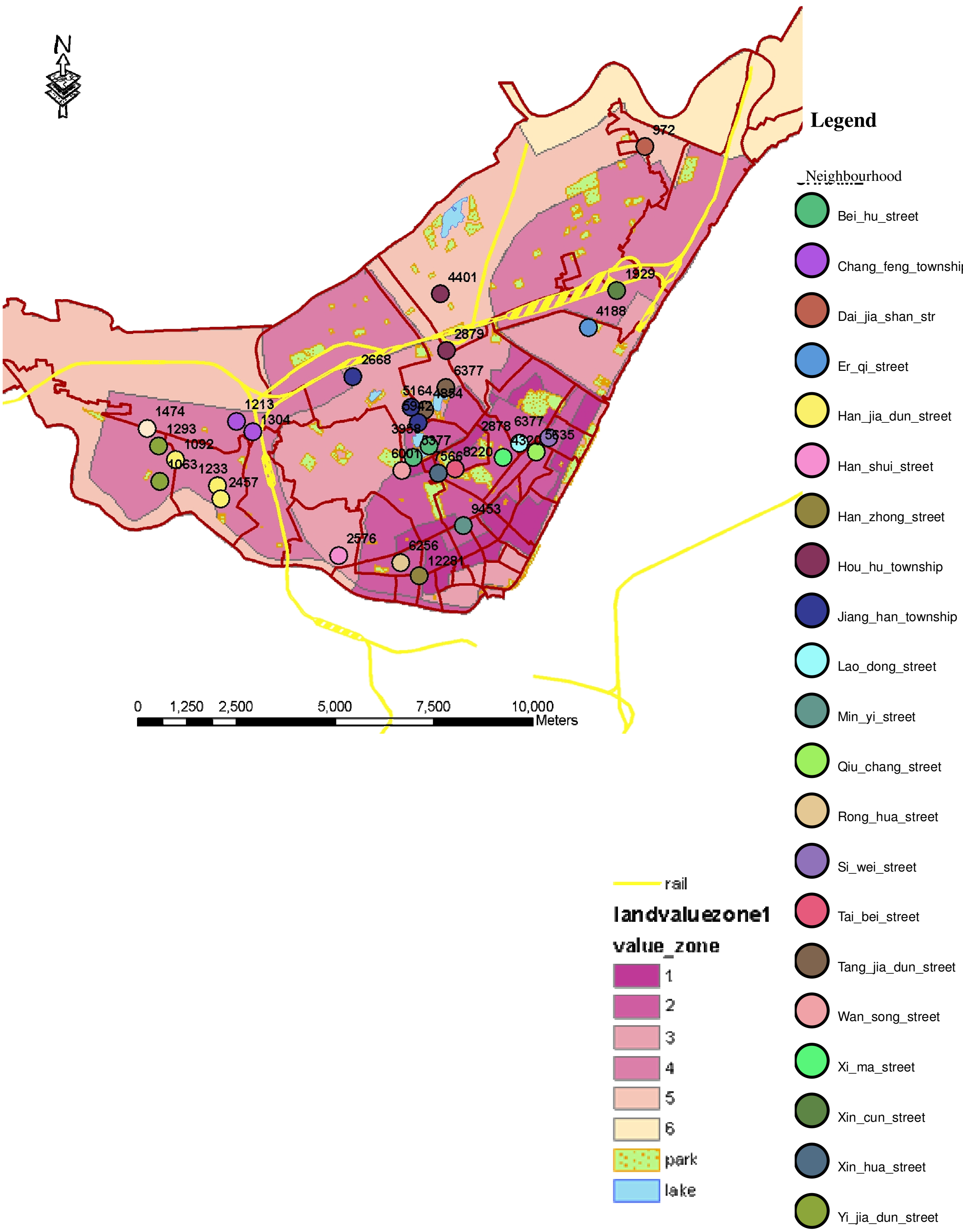
NO_	NETWORK_B	NETWORK
21	12124	6.83684
17	12124	7.99214
18	12124	8.80846
66	12124	10.3379
81	12124	10.3021
41	12124	13.263
40	12124	6.31761
65	12124	12.6207
20	12124	9.91335
23	12124	20.6471
26	12124	17.9647
27	12124	18.9553
34	12124	21.8076
35	12124	19.3248
46	12124	16.4165
85	12124	17.153
71	12124	22.0151
36	12124	8.16401
59	12124	6.67034
58	12124	3.84101
73	12124	6.7786
70	12124	8.35225
83	12124	17.878
56	12124	19.3706
67	12124	27.6638
82	12124	9.75819
84	12124	10.9232
64	12124	8.63482
91	12124	6.61704
93	12124	16.6099
94	12124	7.46005

Appendix 8: Comparison with the benchmark price and actual market price

Reference land value		Sample		Descriptive case	FAR
Zone	Benchmark price	ID	Adjusted Market prices		
1	4398	40	5377	+	2.31
2	3221	21	6001	+ +	4.45
		20	2878	-	2.95
		59	6256	+ ++	4.5
		58	9453	+ + + +	4.10
		70	4320	+	3.0
		82	6377	+ ++	3.5
		64	5635	+ +	4.0
		91	7566	+ + +	3.2
		94	8220	+ + +	4.1
		17	3958	+	2.21
		73	12281	+ + + + +	5.50
3	(2330)	18	5942	+ + +	3.02
		66	5164	+ +	3.50
		36	2576	+	1.62
		41	2879	+	2.20
		65	2668	+	2.80
		81	6377	+ + +	3.80
		84	4854	+ +	3.80
		83	4188	+ +	2.5
4	1731	23	1304	-	1.18
		26	1233	-	1.50
		27	1092	-	1.57
		34	1293	-	1.59
		35	1063	-	1.57
		46	2457	+	1.80
		85	1213	-	1.50
		71	1474	-	1.44
		56	1929	+	1.76
5	(1268)	67	972	-	1.50
		93	4401	+++	2.09

Notes: "+" means less than 1000 extra profit. "++" means more than 1000, but less than 3000 extra profit; "+++"means more than 3000, but less than 5000 extra profit; "++++"means more than 5000, but less than 7000 extra profit; "+++++"means more than 7000 extra profit; "-" means lower than the benchmark price.

Appendix 9: Distribution of sample in neighborhoods



Appendix 10: Access table of travel time calculation of new data set

Attributes of testsample_f point

point:TESTSAMPLE_F#	result:NETWORK	result:NETWORK#B	result:NETWORK
1	12071	12215	15.6383
2	12089	12215	8.92349
3	9873	12215	9.93738
4	9889	12215	11.6317
5	6627	12215	16.1684
6	3310	12215	23.6678

Appendix 11: Database of the dependent and independent variables

	No	ARA	FAR	AJU	COP	NEQ	POL	AME	HOP	POS	NEW	NERI	SCH	MAK	MAR	BUS	ACC	ACS
1	17	21693	2.21	3958	3221	80	100	100	1000	1600	1	0	4.87	300	50	2	7.99	838.00
2	18	14227	3.02	5942	2330	80	100	100	700	1600	1	0	4.05	300	50	2	8.81	1203.0
3	20	6101	2.95	2878	3221	80	100	80	300	500	0	0	2.11	300	50	2	9.91	1008.0
4	21	3817	4.45	6001	3221	80	100	100	1200	1200	0	0	5.67	300	50	2	6.84	1603.0
5	23	46420	1.18	1304	1731	80	100	50	700	1600	0	1	7.13	700	50	3	20.65	1125.0
6	26	73263	1.50	1233	1731	80	100	50	1000	300	0	0	8.33	1000	50	2	17.96	375.00
7	27	141858	1.57	1092	1731	50	100	50	300	900	0	0	6.84	300	50	2	18.96	375.00
8	34	17521	1.59	1293	1731	50	100	50	1000	1600	0	0	6.77	300	50	2	21.81	590.00
9	35	142536	1.57	1063	1731	50	100	50	700	1200	0	0	5.96	1000	50	2	19.32	750.00
10	36	2276	1.62	2576	2330	80	100	50	1000	1600	0	0	4.02	700	50	2	8.16	677.00
11	40	2896	2.31	5377	4398	100	100	100	1200	1600	1	0	4.53	300	50	2	6.32	1592.0
12	41	7344	2.20	2879	2330	80	100	80	700	500	0	1	5.58	300	50	1	13.26	350.00
13	46	76477	1.80	2457	1731	80	100	80	1200	500	1	0	8.96	1000	50	2	16.42	500.00
14	56	13612	1.76	1929	1731	80	100	80	700	700	0	1	6.25	1000	50	2	19.37	750.00
15	58	12035	4.10	9453	3221	100	100	100	300	1600	0	0	2.77	500	80	2	3.84	969.00
16	59	7740	4.50	6256	2330	80	100	80	500	500	0	0	6.43	500	50	2	6.67	1076.0
17	64	112950	4.00	5635	3221	80	100	50	500	900	0	0	.61	500	50	2	8.63	487.00
18	65	10941	2.80	2668	2330	80	100	50	1200	300	0	1	4.27	700	50	3	12.62	745.00
19	66	11270	3.50	5164	2330	80	100	80	1000	1600	0	0	5.58	300	80	2	10.34	1298.0
20	67	4444	1.50	972	1268	50	50	50	1000	1600	0	0	4.67	1000	100	3	27.66	4449.0
21	70	10585	3.00	4320	3221	100	100	100	500	900	0	0	1.78	300	50	2	8.35	1125.0
22	71	49536	1.44	1474	1731	50	100	50	1200	1600	0	0	6.49	1000	50	3	22.02	1270.0
23	73	16880	5.50	12281	3221	80	100	80	300	500	1	0	3.30	300	100	2	6.78	451.00
24	81	11782	3.80	6377	2330	100	100	100	300	700	1	0	.86	300	100	2	10.30	830.00
25	82	16769	3.50	6377	2330	100	100	100	700	900	0	0	6.39	300	50	1	9.76	254.00
26	83	311844	2.50	4188	2330	100	100	100	300	700	0	0	5.98	1000	50	2	17.88	1498.0
27	84	21630	3.80	4854	2330	80	100	100	500	1600	1	0	2.80	300	80	1	10.92	1213.0
28	85	19879	1.50	1213	1731	80	80	50	300	1600	0	0	6.98	700	50	3	17.15	1427.0
29	91	7147	3.20	7566	3221	100	100	100	1000	1600	1	0	4.95	500	100	2	6.62	1417.0
30	93	1113	2.10	4401	1268	80	100	100	1000	500	0	0	8.31	1000	50	3	16.61	1875.0
31	94	6800	4.10	8220	3221	100	100	100	500	1600	0	0	4.65	500	80	2	7.46	1088.0

Appendix 12: Process of network calculation