Analysis of Nanjing Land Value Through PLVI Modeling——Based on Bidding Theory

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Abstract—In the 1960s, the general relationship between land value and the distance from CBD is through a basic model, the bid rent theory, which is drawn on a concept from microeconomics and is based on the work of Alonso (1964) & Muth (1969). Through relevant data analysis under the model of PLVI, this study aims to investigate this relationship more accurately and focus on whether the value of land decreases as the distance from the CBD increases. The author further discusses the principles and characteristics of the current situation in combination with specific cases in Nanjing. Qualitative and quantitative methods are both involved in this essay. Specifically, the core-frame model of CBD in Jianye district is applicable to clearly explain the structure of PLVI so as to highlight its economic and cultural influence. Besides, spearman's coefficient can be utilized to investigate the relationship precisely in a quantitative way. Primary data and secondary data are both essential, and primary data mainly involves land value and distance statistics, while secondary data is mainly based on basic models and maps. In conclusion, in terms of trends, Nanjing's results conform to the original model, but the value is between 0.5 and 1, which shows that there are still some points that do not conform to this law.

Keywords- Urban environment; Bid rent theory; Land value; Nanjing land price; data analysis

1 INTRODUCTION

In 1960s, the general relationship between land value and the distance from CBD is through a basic model, the bid rent theory, which is drawn on a concept from microeconomics and is based on the work of Alonso (1964) & Muth (1969) [1]. This essay aims to concentrate on whether the land value decrease as the distance to the CBD increases. The general relationship showed the 1960s basic model, the bid rent theory, and the reason of profit-seeking is also explained. However, the model can only illustrate a general relationship, not to mention that it was a product of the 1960s. Therefore, the author intends to investigate such relationship more precisely and delve into the principle under the current situation based on the specific cases in Nanjing, explaining the special features with both quantitative and qualitative analysis to evaluate the model.

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2 OVERVIEW

2.1 The introduction of Jianye District

Jianye District is an emerging district among all the districts in Nanjing. This essay would like to focus on this district, such as its emerging properties including its economy, infrastructure and so on [2].

To be specific, Jianye District is in the southwestern part of metropolitan Nanjing and is adjacent to the Yangtze River and the Qinhuai River. The district is the result of Nanjing's efforts to establish a new modern international city center.

Figure 1 Nanjing District Map [2]

2.2 Land values-Bid rent theory

Bid rent theory is a geographical theory that refers to how the price and demand on land changes as the distance towards the CBD (Central Business District) increases.

Shown in the figure 2, the three main lines are for retail, manufacturing, residential separately.

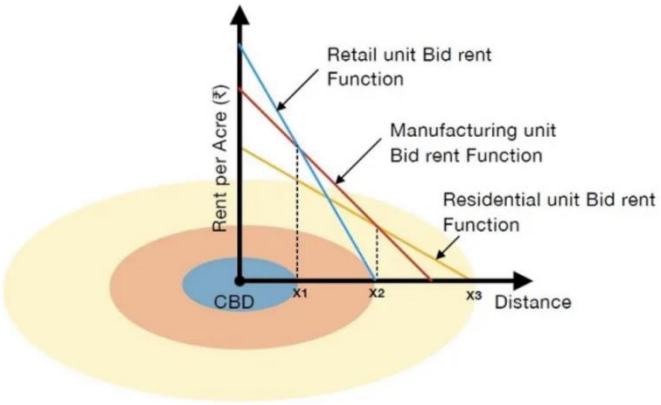

Figure 2. Bid rent theory [3]

Specifically, as for retailing, the bid rent theory shows that commerce is willing to pay the the highest rents and rates. Therefore, the CBD is characterized by offices/high-end shopping etc. Thus, retailing as well as the tallest buildings will be found closet to the PLVI. To explain further, in large cities, the high demand for the space in the center of the city (near the PLVI) drives up the land price or rent so much that high-rise developments become financially viable despite the very high costs of this type of construction [5].

As for residential areas, there are several features shown by the theory. First, the highest density housing areas are in inner city areas (next to the CBD). They are zones of transition. Housing types may include high-rise apartment blocks or terraced housing. Second, residential densities decrease with distance from the CBD, because the land is cheaper and then it can be used less intensively. Therefore, detached houses can be built on large plots.

3 HYPOTHESIS

According to the bid rent theory shown above, the starting point of the model will be the Peak Land Value Intersection (PLVI) which is the point with the highest land value. As the distance from the PLVI increases, all kinds of land values, involving retailing, manufacture and commercial, and residential, will all show a trend of decreasing.

In Jianye district, according to such theory, the author supposes that the distance from the CBD, the Nanjing Golden Eagle International Shopping Centre increases, both the land rate and rent of residential area will decline in general. However, special points that do not follow such trend are ought to occur, because the urban morphology of a city is the result of the urban dynamics, or process which changes all the time.

4 METHODOLOGY

This essay employs both primary and secondary resources:

The distance away from the PLVI is included in primary resources, as well as the rate or rent of housing. As for this aspect, the method is used to firstly go through the street along the direction either north-eastward or south-westward, with a record of every residential zone's rent and purchasing price by immobile agency app and a record of distance away from the the PLVI by map app. After that, the Calculate Spearman's coefficient between the distance away from the PLVI and the rent of residential area, and the distance away from the PLVI and purchasing price of residential area will be carried out.

The composition of CBD in Jianye district and its transportation route are the secondary resources based on the data of Baidu Map APP, including re-modeling based on the core-frame model.

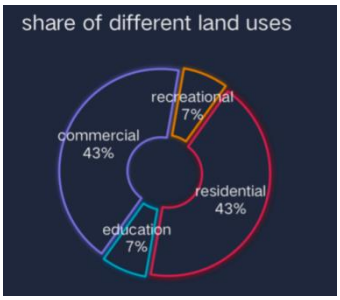

Figure 3. Share of different land uses in Jianye District

All indicators are chosen for proper reasons. The detailed introduction to CBD can clearly show its structure and purpose. Besides, through the first-hand data of walking distance measurement from the CBD and the rate or rent of the passing houses, it is easy to find out the intuitive impact of time and space changes on the land value.

As for the reason why choose to investigate the land value of residential area in Jianye District, it is shown in the figure above (Fig.3). It is obvious that the residential area takes up a large proportion of land use, reaching 43% of the total share. Specifically, unlike commercial land value which is tightly related to the profit only, there are many specific factors can determine the land value of residential area in Nanjing, including School District Housing and the holding of public campaigns such as Youth Olympic Games.

5 DATA PRESENTATION & ANALYSIS

5.1 Modeling of PLVI

The model above shows the basic composition of a PLVI, and CBD in Jianye District follows the structure as well. In other words, the author intends to use this Simplified model to describe the PLVI in Jianye district.

Specifically, the inner core, shown by the blue color, mainly contains four types of buildings. These buildings are department stores involving Nanjing Golden Eagle International Shopping Centre (Yingtian Avenue Store); specialist shops involve VICTOR Olympic Sports Store; high-rise offices involve Deying Building; commercial offices or banks involve Bank of China.

As for the outer core shown in orange color, there are five main functional buildings. The first type is insurance corporation involving CCB Life Insurance, People's Insurance of China. Then it comes solicitor, including Beijing Kangda (Nanjing) Law Firm, Jiangsu Zhenyu Law Firm (Wanda Store). The third and fourth types are the public administration involving New Town Building, Administrative Service Hall Government Service Center, theatres and cinemas including Wanda Cinema. The fifth type also occurs in the inner core, which is the specialist shops, but what different is that the number of such stores increases. In this area, there are three specialist shops, such as Fall in love with the city mother and baby, Decathlon, Archaeopteryx.

The final part of yellow color is the frame which has seven main commercial activities, including education such as Nanjing Nanhu Second Middle School; small low grade shops such as 711 Convenience Store; transport terminal such as Jiqingmen Street Subway Station; car parking such as Hexi Building Parking Lot; car sales such as Jiangsu Huaxing Deep Blue Automobile Co., Ltd.; warehouses and limited manufacturing such as Ndong glass processing plant; wholesale services such as Changhong Market.

In addition, the two areas A and B show the dynamic development possibilities of PLV I. The Zone of Assimilation is an area that is relatively fluid and can move. This corresponds closely to the gentrification argument. At the same time, Zone of Discard is an area turning to be cut down, because a major employer decided to leave due to a lack of investment in the urban infrastructure.

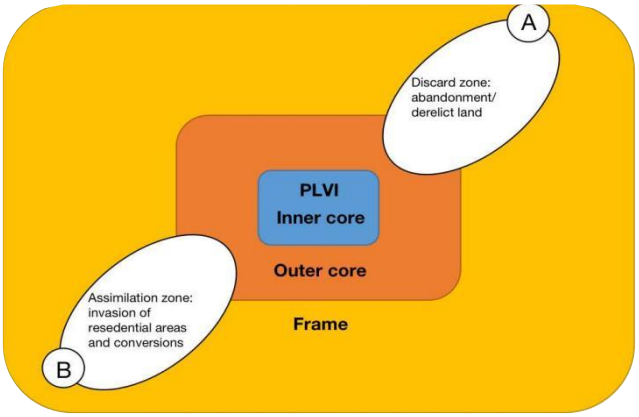

Figure 4. Secondary modeling based on the city's situation on the core frame modell of PLVI [7]

5.2 Relationship between land value and the distance from PLVI

The Table above is the result of the research, requiring to go through mathematics to get a more accurate conclusion. Moreover, given some minor factors may lead to errors in judging the relationship, some more information including the year of completion, area and quality of property and supporting are also collected.

Table 1 Land value around PLVI

Residential district name (Residential land/ commercial housing)	Year of completion	Area(㎡)	Rent(￥/month)	Recent average sales price(￥/㎡)	Quality of Property and supporting
Wan he yuan ju	2005	fully furbished 98 ㎡	5300	42550	Middle
Ji shan xin yu	2003	fully furbished 89 ㎡	4900	39970	Low
Hua run yue fu	2014	fully furbished 189 ㎡	18000	63850	High
Jin di ming jin	2010	fully furbished 88 ㎡	6500	52062	High
Hong da xin yu	2000	fully furbished 89 ㎡	5000	45588	Middle
Xing yu hua fu	2011	fully furbished 93 ㎡	6500	56819	High
Yin lun hua yuan	2000	fully furbished 89 ㎡	5000	41825	Low
Yue da xin yu	2000	fully furbished 67 ㎡	3800	44673	Middle
Tai da xin yu	2000	fully furbished 138 ㎡	6500	36281	Low
Jin ling shi jia	2000	fully furbished 150 ㎡	6500	37882	Middle
Xin xi jia yuan	2001	fully furbished 129 ㎡	5500	35178	Middle
Mei li jia yuan	2002	fully furbished 110 ㎡	5500	44370	Middle
Su jian hao ting	2005	fully furbished 97 ㎡	4800	40327	Middle
Xing da xin yu	2000	fully furbished 85	5300	39970	Middle

		㎡			
Heng tang xi yuan	2009	fully furbished 91 ㎡	5300	49005	High
An ru cun	1997	Ordinary decoration 49 ㎡	2800	33972	Low
Feng huang he xi	2010	fully furbished 90 ㎡	6800	56056	High
Zhong bei ying jun	2014	fully furbished 90 ㎡	6200	53638	High
An kang cun	1994	fully furbished 77 ㎡	4200	33312	Low
Qi ting	2010	fully furbished 105 ㎡	7000	50548	High
Hai yue ming du	2012	fully furbished 128 ㎡	14000	78701	High
Hong tu shang shui yun jin	2016	fully furbished 115 ㎡	9000	74906	High

5.3 Spearman's coefficient

Spearsmam's coefficient is a kind of formula examining the correlation between the data-sets. The result is $-1 \leq Rs \leq 1$, with the sign showing whether the two positively correlated, and the value itself indicates how strong such relationship is.

The formula to calculate the coefficient is shown below:

$$Rs = \frac{\sum D^2}{n(n^2-1)} \quad (1)$$

The Table 2 below is based on the Table1, while adding the rank of distance from the PLVI, Rank1 of rent as well as Rank2 of recent average rate. Besides, the difference of different ranks is shown here, with Difference1 indicating the difference between Rank and Rank1, and Difference2 showing the difference between Rank and Rank2 (all the values are absolute value).

Table 2 Spearman's coefficient

Residential district name (Residential land/ commercial housing)	Distance from Hexi Golden Eagle International Convention (m)	Rank	Rent (￥/month)	Rank 1	Difference 1	Difference squared 1	Recent average sales price (￥/㎡)	Rank 2	Difference 2	Difference squared 2
Wan he yuan ju	200~300	22	5300	14	8	64	42550	13	9	81
Ji shan xin yu	300~400	20.5	4900	18	2.5	6.25	39970	16.5	4	16
Hua run yue fu	300~400	20.5	18000	1	19.5	380.25	63850	3	17.5	306.25
Jin di ming jin	400~500	18.5	6500	7.5	11	121	52062	7	11.5	132.25
Hong da xin yu	400~500	18.5	5000	16.5	2	4	45588	10	8.5	72.25
Xing yu hua fu	500~600	15	6500	7.5	7.5	56.25	56819	4	11	121
Yin lun hua yuan	500~600	15	5000	16.5	1.5	2.25	41825	14	1	1
Yue da xin yu	500~600	15	3800	21	5	25	44673	11	4	16
Tai da xin yu	500~600	15	6500	7.5	7.5	56.25	36281	19	4	16
Jin ling shi jia	500~600	15	6500	7.5	7.5	56.25	37882	18	3	9
Xin xi jia yuan	600~700	11	5500	11.5	0.5	0.25	35178	20	9	81
Mei li jia yuan	600~700	11	5500	11.5	0.5	0.25	44370	12	1	1
Su jian hao ting	600~700	11	4800	19	8	64	40327	15	4	16
Xing da xin yu	700~800	8.5	5300	14	5.5	30.25	39970	16.5	8	64
Heng tang xi yuan	700~800	8.5	5300	14	5.5	30.25	49005	9	1.5	2.25
An ru cun	800~900	6.5	2800	22	15.5	240.25	33972	21	14.5	210.25
Feng huang he xi	800~900	6.5	6800	5	1.5	2.25	56056	5	1.5	2.25
Zhong bei ying jun	900~1000	3	6200	10	7	49	53638	6	3	9
An kang cun	900~1000	3	4200	20	17	289	33312	22	19	361

Qi ting	900~1000	3	7000	4	1	1	50548	8	5	25
Hai yue ming du	900~1000	3	14000	2	1	1	78701	1	2	4
Hong tu shang shui yun jin	900~1000	3	9000	3	0	0	74906	2	1	1

When using $\frac{\sum D^2}{n(n^2-1)}$ to calculate Rs, the coefficient of relationship between Rank and Rank1 is 0.835(0.5<0.835<1).

According to Rs calculated above, generally speaking, there is a strong correlation between the rent and the distance from the Hexi Golden Eagle International Convention, with several points deviating from the pattern.

When using the same formula to deal with the relationship between Rank and Rank2, the result is 0.874(0.5<0.835<1).

According to Rs calculated above, there is also a strong correlation between the purchasing price and the distance from the Hexi Golden Eagle International Convention, but there are still some points not following the trend.

Through the calculation of the relationship among them (Rank, Rank1, Rank2), it can be preliminarily judged that the conclusion of bid rent theory is applicable to Nanjing. However, both values are only around 0.8, showing that if the author brings it into larger data, there will be more cases that do not meet the trend, which requires the following exploration for the reasons.

6 REASON EXPLANATION

According to the data analyzed above, the author can find that for Nanjing, although the land value and distance from PLVI have a logical relationship, the relationship is actually very weak from the numerical value. From my perspective, this is mainly because many secondary peak land value intersections have emerged. Specifically, under the case of Nanjing, two factors are worthy of attention. One is a short-term factor, which is holding Youth Olympics, the public campaign; the other is symbolic in China, such as school district room which is included in the educational effect.

6.1 Youth Olympics

The 2014 Nanjing Youth Olympic Games, also known as the Nanjing Youth Olympic Games, opened at 20 o'clock on August 16, 2014 in Nanjing, China. The Nanjing Youth Olympic Games is another major Olympic event in China after the Beijing Olympics. It is the first Youth Olympic Games held in China and the second Olympic Games held in China [6]. Because of the campaign, a new secondary PLVI, the Olympic park, has been constructed.

The data of land value this area that can better show the basic relationship in bid rent theory has been broken down.

Table 3 The land value of PLVI Olympic park

Residential zone	Distance away from the Olympic park (m)	Rank	Rent	Rank1	difference1	difference squared1	Purchasing price	Rank2	difference2	difference squared2
Dan Guiyuan	885	5	6576	2	3	9	65000	2	3	9
Dan Fengyuan	901	1	4525	5	4	16	61673	3	2	4
Mu Xiyuan	897	3	5012	4	1	1	61529	5	2	4
Hai Tangyuan	892	4	5543	3	1	1	61635	4	0	0
Zi Weiyuan	899	2	9000	1	1	1	76388	1	1	1
Result						-0.4				0. 1
rong qiao zhong yang hua yuan feng shu jie qu	1300	5.5	3182	6	0.5	0.25	59500	5	0.5	0.25
jin ma li cheng(dong qu)	1300	5.5	3281	4	1.5	2.25	64000	3	2.5	6.25
bi yao hua yuan dong yuan	1700	1	3204	5	4	16	59000	6	5	25
rong qiao zhong yang hua yuan mei gui jie qu	1700	1	3379	3	2	4	62000	4	3	9
hua xin cheng jing yuan	1400	4	4827	1	3	9	78000	1	3	9
hua xin cheng jun ting	1600	3	4436	2	1	1	69000	2	1	1
			(per 70 m^ 2)			32.5				50.5
Result						0.071428571				-0.442857143

Generally, as for the rent, there is nearly no correlation between the renting price and the distance from the Olympic park. As for the reasons, the renting price of a house may depend more on the community and the house itself rather than the distance to the Olympic Park.

At the same time, as for the rate, it shows a slight correlation between the purchasing price and the distance from the Olympic park, with many points not following the pattern. As for the reason, the house price may be mainly related to the infrastructures around to a greater extent than the distance to the Olympic park. For instance, there is a secondary school near Rong Qiao Zhong Yang Hua Yuan Feng Shu Jie Qu (¥59500) and a primary school near Bi Yao Hua Yuan Dong Yuan (¥59000). Besides, because of being located near a commercial area called Huacaitiandi, Hua Xin Cheng Jing Yuan and Hua Xin Cheng Jun Ting has the highest two purchasing prices, up to ¥78000 and ¥69000 per square meter.

6.2 Education

According to the Spatial and Temporal Effects of Housing Price in Urban School Districts Based on Education Equity: A Case Study of Public Pimary School in the Main Urban Area of Nanjing [4], housing prices in the main urban areas generally show a “core-side” structure that the famous schools centered in the inner city, and decreased towards the periphery basically. This is because the high-quality basic educational resources in the main urban area of Nanjing are mainly distributed in the northern inner city and its neighboring Hexi New Town Long Jiang Pian District. Besides, the spatial pattern of high-quality educational resources is relatively stable.

The pattern of educational resources is similar to the spatial pattern of housing prices. That means higher-quality educational resources are distributed in areas with high housing prices, and educational resources in areas with low housing prices are generalized. With the rise of "school district housing", the improvement of the quality of educational resources will play a role in boosting the price of regional housing. For example, the rapid development of Hexi New Town and the improvement of educational quality will undoubtedly develop a new housing price in Nanjing.

The quality of educational resources has obvious phased effects on housing prices [4]. In 2008, the quality of educational resources had a relatively weak impact on housing prices, and the regularity of the intensity of the impact was relatively poor. Around 2010, "school district housing" was gradually understood by the society, and gradually used by developers as a tool for publicity. With the increasing demand for school district housing, the quality of educational resources has an increasing impact on housing prices. In 2017, the quality of educational resources has become a key factor affecting housing prices, and the intensity of the impact also shows a certain degree of regularity [4]. It shows that high-quality school districts have a strong impact on housing prices, while ordinary school districts have a weaker impact on housing prices.

7 CONCLUSION

The investigation proves that the hypothesis is mostly correct. The bid rent theory cannot follow the current Nanjing in time and space, which means that the original model is not time-sensitive and universal. Fundamentally, it is because the bid rent theory is based on the fundamental idea of urban development which was found through the investigations towards US cities. Therefore, this model may not be universal in itself, especially for today after many years.

In addition, for this research, there are several evaluation points that need to be clarified:

Fundamentally speaking, the use of rent and rate to represent land value may still be somewhat one-sided, as shown in the first Table in this article. Whether it is the degree of decoration, the year of completion, or the responsibility of the community property, they will affect the judgment to some extent.

In the part of cause analysis, although short-term and long-term classifications are considered, those potential factors or future planning will also have a huge impact on the land value, but this is not known by the naked eyes or investigation. A good example is the planning of subway routes. Specifically, Nanjing is going to construct a large number of new subway routes from 2024 to 2030, which will have a good impact on housing prices.

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