DETERMINANTS OF THE SPATIAL DYNAMICS OF HOUSING PRICES IN CHENGDU, CHINA, 2005 – 2010

by

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Submitted to the Program in Real Estate Development in Conjunction with the Center for Real Estate in Partial Fulfillment of the Requirements for the Degree of Master of Science in Real Estate Development

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ABSTRACT

Housing unit prices differ among 75 street blocks per time period in Chengdu, China. Housing unit price's appreciation also moves differently in the 75 street blocks between 2005 and 2010. With solid transaction data acquired from Chengdu Housing Administration Department, two regression models, Level Model and Change Model are exercised to explore two questions: What are determinants of cross-section housing unit price difference and what are determinants of housing unit price movement in time? The findings are consistent with urban economic theory and actual practice in the market. In conjunction with physical attributes and locational features, the thesis found from the Level Model that economic and demographic characteristics, which are representations of urban economic growth, industrial restructuring and demographic transformation, are also significant determinants that have been capitalized into housing unit price at various levels. In a rapid developing city like Chengdu, the thesis found from the Change Model that instead of the change of various factors, inherent locational features and the initial price per street block play significant roles moving unit price upward in both short-term (1-year) and relatively long-term (5-year). Such finding exhibits consistent market anticipation that housing and amenity demand constantly outpace its supply in Chengdu. Additional Level Models defined by unit size reveal differentiated capitalization effects from same group of locational features. The result ties various sizes of units with corresponding housing products. Subsequently it proves that demographic structure is a significant determinant of housing price dynamics. Field trip and interview are conducted to bridge academic analysis with real market. The findings from qualitative research contribute valuable inputs to improve the models. Understanding determinants that are capitalized into price and move price appreciation is useful to household to guide wise investment. The research is also referable to developer who can make sound assessment on developable land with better understanding of its potential value. The more inclusive analysis of spatial housing price dynamics will assist policy maker to establish proper urban policy in the effort to balance urban structure between housing and jobs.

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Title: Professor of Real Estate Finance, Chair of MSRED Committee
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The pursuit of study of real estate finance at MIT is driven by my dream and aspiration. I've been dreaming about back to school for so long after eight-year's practice as an architect. I aspire to make a middle-career switch from design to real estate investment/development in China. Such objective inspires me to identify a thesis topic that on the one hand will enable me keeping honing quantitative skills, and on the other hand integrate my experiences in space market in China with its fast urban development, especially in the housing market. The vision was not clear until Professor David Geltner from MIT introduced me to Professor Siqi Zheng from Institute of Real Estate Studies, Department of Construction Management, Tsinghua University. Both professors led me to a clearly-defined and workable topic. Without your continuous and constructive guidance, I would not be able to take solid steps building up the thesis so meaningful and valuable. You have my greatest gratitude from the bottom of my heart!

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THIS THESIS IS DEDICATED

To my wife, Jing Wen, for your love, understanding and encouragement all the time!

And

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1.1 Research Motivation and Objective

Chengdu's housing market is rising correspondingly to the growth of the city in the past seven years. Between 2005 and 2011, the city's population grew by 7.5% to 11.7million, household number grew by 21% to 4.43million families, and annual disposable income per capital (nominal RMB) grew by 111% to ¥23,932 ($3,800 in US dollars).[1] The growth of city stimulates increasing demand and supply of housing market. A transaction dataset drawn from Chengdu Housing Administration Department is acquired by Professor Zheng and her team from Institute of Real Estate Studies, Department of Construction Management, Tsinghua University. Most transactions are new condominiums. The dataset shows an upward trend of transaction amount between 2005 and 2010(Fig.1). The dataset also exhibits that annual housing unit price grows 200% from ¥3,645(2005) to ¥7,419(2010) per square meter in five years. (Fig.2)

Year	Samples
2005	48,842
2006	68,315
2007	105,425
2008	56,581
2009	150,493
2010	83,436
Total	**513,092**

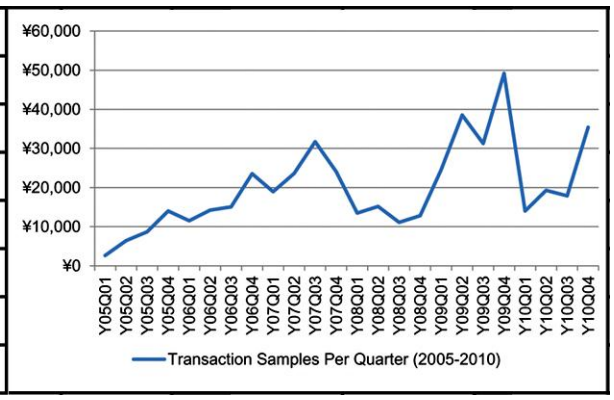


Figure 1. Transaction Samples Distribution (2005-2010), Chengdu[2]

[1] Source: Chengdu Yearbooks, local municipal bureau of statistics. www.cdstats.chengdu.gov.cn

[2] Source: *Construction & Application of GIS Based Spatial Database of New Commercial Housing Transactions - Analysis of Subway Effect & Refinement of "City-Level Housing Price Index"*, by Institute of Real Estate Studies, Tsinghua University, Oct.2010

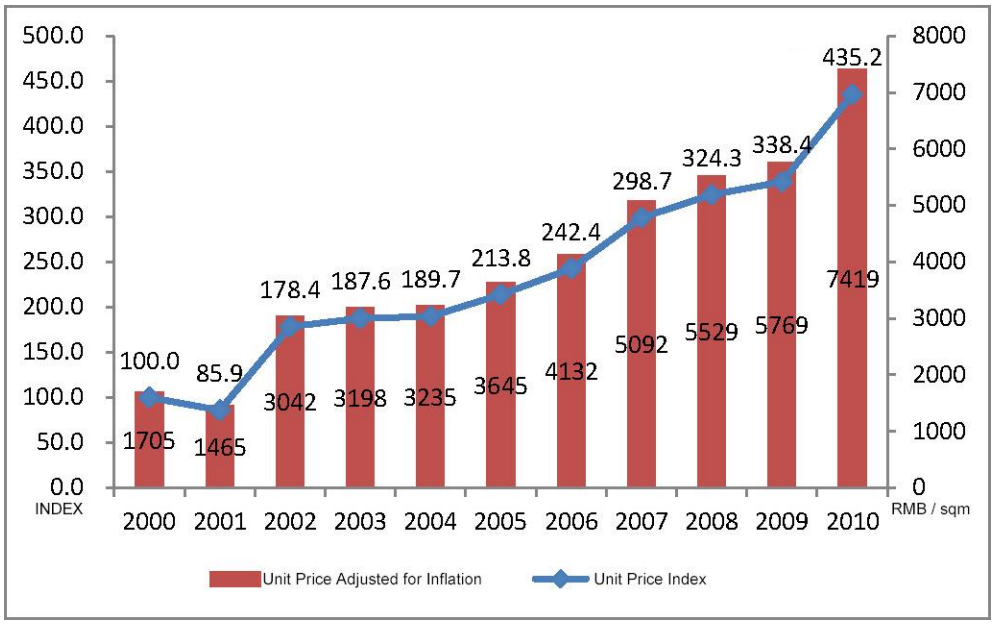


Figure 2. Housing Unit Price & Index (2005-2010), Chengdu[3]

Further intra-city study reveals cross-section variations of housing supply and unit price. Figure 3 exhibits cross-section distribution of cumulative transactions (2005-2010) based upon geographic region defined by ring road. More than 50% of transactions locate between 2nd and 3rd ring road, with the 2nd largest transactions at outside 3rd ring road.

Region Defined by Ring Road	Transaction Samples cumulative (2005-2010)
Inside 1st Ring	31,980
Between 1st & 2nd Ring	45,607
Between 2nd & 3rd Ring	268,992
Outside 3rd Ring	116,982

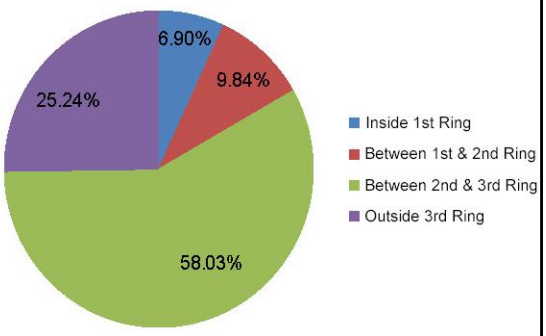


Figure 3. Geographic Distribution of Cumulative Transactions (2005-2010), Chengdu[4]

[3] Source: *Spatial Relationship Analysis of City Dynamic Based "Housing-Jobs"- Study Using The Core of City Chengdu As Example,* by Institute of Real Estate Studies, Tsinghua University, Nov.2011

[4] Source: *Construction & Application of GIS Based Spatial Database of New Commercial Housing Transactions - Analysis of Subway Effect & Refinement of "City-Level Housing Price Index"*, by Institute of Real Estate Studies, Tsinghua University, Oct.2010

Figure 4 exhibits both cross-section average unit price difference and unit price movement in temporal series between 2005 and 2010. Unit price generally moves downward as it is further away from CBD, a typical characteristic of monocentric city. Some areas further away from CBD show higher unit price than some areas closer to CBD. Volatility of unit price in time is different. Although the price appreciates in most time, the level of appreciation varies cross different geographic location.

Distance to CBD	Average Unit Price 2005-2009, RMB/Sqm
<1 km	6,644.7
1-2 km	6,010.9
2-3 km	5,659.4
3-4 km	5,260.4
4-5 km	5,916.9
5-6 km	5,851.9
6-7 km	5,699.7
7-8 km	5,349.1
8-9 km	4,701.9

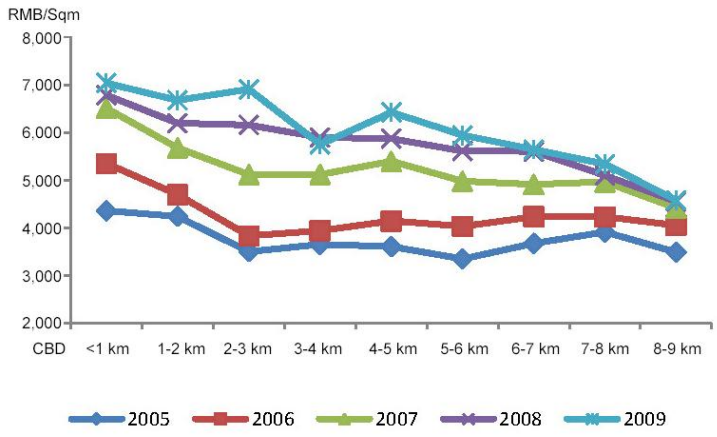


Figure 4. Housing Price Cross-Section & Temporal Movement (2005-2009), Chengdu[5]

Why unit price cross-section is different and why price movement is different in time are the focuses of the paper. Chengdu is an ideal city exploring intra-city housing price dynamics because of a couple reasons (1) Monocentric city with limited social goods mostly located in the core of the city; (2) Rapid growth of housing market supply and unit price, evidently supported by solid dataset; (3) Fast urban growth, economic restructuring and demographic transformation,

[5] Source: *Spatial Relationship Analysis of City Dynamic Based "Housing-Jobs"- Study Using The Core of City Chengdu As Example,* by Institute of Real Estate Studies, Tsinghua University, Nov.2011

evidently supported by relatively acceptable data drawn from yearbook of local municipal bureau of statistics at www.cdstats.chengdu.gov.cn.

The dataset provided by local municipality to Institute of Real Estate Studies, Tsinghua University contains total 513,092 transaction observations, most of which are new housing units transacted for first time in market between 2005 and 2010. In contrast to sub-market focused samples by consulting firms, the dataset is more authoritative and complete, with comprehensive information of individual transaction. Meanwhile, both the data samples and locational features, such as distance to CBD, location and number of subway station, shopping mall, core primary school, river and access to interstate highway are geocoded to GIS map. Available supporting information for various research topics includes sample survey of residents' living conditions by National Bureau of Statistics and National Economic Census of Industrial Sectors & Employment Status in Chengdu.

Since 2005 Chengdu initiated critical movements to reorganize economic geography and restructure industrial structure. The objective is to upgrade its economic pillars from manufacturing industry to service industries including insurance, finance and real estate. Manufacturing began to be relocated from the core of city, a historic result since the new founding of China in 1949, to the periphery, mostly to southern city. Service industries are initially being encouraged to concentrate at inner city, later growing to between 1st and 2nd ring as the inner city becomes full. Construction of city's first subway (line1) began in 2006 and started operation in October 2010. Construction of city's second subway (line2) began in 2008 and will be in operation by end of 2012. North-South orientated subway line1, like a spoke, connects 1st and 2nd ring roads, and amplified the economic agglomeration of the inner part of the

city for service industries. In contrast to the large investment to improve city's infrastructure, housing market develops behind and new commercial housing units are undersupplied. The illiquidity of existing housing market exacerbates the imbalance between housing and jobs. The growth of the city and the increasing amount of flow-in migrants outpaced the development of infrastructure and public amenities, the existing of which are scarce and only concentrated in the core of the city. The physical attributes, locational features, and economic/demographic characteristics of street block will determine housing cross-section unit price difference and its movement in time.

In comparison to other urban economic studies cross China, intra-city housing price analysis was empirically understudied due to lack of solid data and rapid urban growth. Research and model of housing price dynamics presently largely focus on capitalization effect on housing units' physical attributes, locational amenities and public goods. The role of economic restructuring and urban growth is left out. These features should have significant impact on housing price difference and movement, especially in city like Chengdu which is undertaking rapid and substantial transformation of social, economic and demographic fundamentals. In addition to academic objective of this research, fluctuation in housing price has important ramification for general economy and consumption. In China, number of investment vehicles is small and housing unit is the predominant tool investing in fixed property. Households spending large share of disposable income on housing not only look for place to live but also consider it long term family investment. Deep understanding of what factors are capitalized into housing price can become useful guideline to invest wisely. The research can be also valuable to developers who can refer to the research to make sound assessment on developable land with better

understanding of its potential strength. The more inclusive analysis of spatial housing price dynamics can also assist policy maker to establish reasonable urban policy in the effort to balance urban structure between housing and jobs.

1.2 Research Methodology and Organization of the Paper

Learning from the literatures about housing price dynamics in Boston MSA and Hong Kong, the research adopts both quantitative and qualitative analyses. On the quantitative side the transaction dataset is sorted to street block level in the core of the city. Two hedonic models, Level Model and Change Model are tested to explore determinants of unit price difference cross sections and unit price movement in time between 2005 and 2010. Further refined subgroup models based upon unit size are studied at both Level and Change status. Three approaches to measure unit price per street block are adopted as dependent variable in regression model. The definition of street block adopts the same approach applied in Chengdu Population Census and Economy Census. 75 street blocks are identified within five administrative districts inside the core of city.

The first regression model is classic hedonic model named Level Model. The exercise tests determinants of unit price difference cross section. Mean price of 75 street-block data is dependent variable on the left hand side of the equation. Three main classes of explanatory variables are on the right hand side: (1) Physical attributes of housing unit; (2) Distance to locational amenities and public goods; (3) Economic indicators and demographic characteristics. Year dummy and TianFu_Zone dummy (refer to section 4.3) are introduced. The second

hedonic model, called Change Model, studies determinants that decide unit price movement in time. Both short-term (1year) and long-term (5year) change are tested. Delta Mean of unit price (1-yr or 5-yr) is dependent variable on the left hand side of the equation. Delta changes of same explanatory variables as Level Model are on the right hand side of the equation at first. Later level variables in the starting year, conceived as initial / inherent attributes replace Delta variables because of their significances and economic meanings. Three measurements are taken to calculate unit price of street block: Project Mean, Unit Mean and Unit Median (refer to section 3.1). Models further refined by unit size (<=90sqm, 90-144sqm, >144sqm) are created at both Level and Change status.

Accompanied with quantitative analysis is qualitative discussion based upon field trip and interview of local market experts. Residual of Preliminary Level Model results between 2005 and 2010 are graphed into GIS diagrams to induce discussion with local market experts. Memorandum of field trip is later reviewed and discussed with Professor Zheng and her team from Institute of Real Estate Studies, Tsinghua University back to Beijing. Model structure is further refined by (1) Introducing three unit price measurements on the left hand side of the model (2) Adding new explanatory variables and dummies (3) Shifting independent variables from Delta to Level in Change Model. Important but non-quantifiable or unavailable information, such as policy, employment, detailed demographic are described in the paper to complement the model results

The exercises yield several findings and reinforce the perception that Chengdu is a classic monocentric city. Results of Level Model indicate that in addition to physical and locational

features, urban growth, economic restructuring and demographic transformation are also important determinants to decide housing price difference cross sections. Factor values of population density, per capita purchase power and per capita fixed investment are all significant in the model result. Sub-grouped Level Models exhibit differed capitalization effects by physical and locational features cross three unit groups (<=90sqm, 90-144sqm, >144sqm). It reveals that different households, represented by size group (corresponding to housing product) have distinctive criteria and concerns to capitalize these characteristics into housing unit price. Results of Change Model reemphasize the characteristic of monocentric city. Instead of delta factor (change of explanatory variables in time), it is level factors that largely determine housing price movement in time series. Level factors include initial unit price at starting year, and the inherent merits such as distance to CBD, Mall and Core Primary School. Change Model results reveal that households not only are willing to pay unit price premium for locations with good public amenities and social goods, they also anticipate that unit price appreciation will be high in these locations. Given the fact that Chengdu is growing rapidly with large number of migrants flowing in, it is not difficult to anticipate that public resources will be continuously scarce and be key determinants to price movement.

The paper is organized as the followings. After literature review on intra-city housing price dynamics in the last section of Chapter1, Chapter2 introduces Chengdu housing market and the city's economic restructuring and urban growth. Chapter3 presents data and model structure. Chapter 4 includes detailed discussions about Level Model and Change Model, before field trip and afterwards, with variations based upon three unit price calculation and three size-based sub-models. Conclusion closes Chapter5.

1.3 Literature Review

Past studies of the relationship between spatial sections and housing price focus on the capitalization of locational amenities and social goods into price. They largely agree that capitalization occurs in the housing market to varying degrees. For example, recent work by Zheng and Kahn (2007)[6] focuses on the impact of housing complex's physical attributes, locational characteristics and social goods on Beijing's housing price. The argument is that physical features are important determinants and capitalized significantly into housing prices. Given the undersupplied and unevenly distributed public goods and amenities, it is expected that comparable findings are also obvious and significant in Chengdu housing market.

In contrast to the large number of studies looking at amenity capitalization, only a small body of research explores the nature and variation in neighborhood level housing price dynamics. For instance, in a detailed examination of the question, Case and Mayer (1996)[7] examined housing price appreciation in neighborhoods of the Boston. They found that variations in growth rates across the neighborhoods were associated with differences in neighborhood features, such as location specific amenities, demographics, and the employment structure of the city. Specifically, they found that declines in the importance of the manufacturing sector were concurrent with lower growth rates in towns with a high share of manufacturing employment. Building on this article, the Change Model of the paper applies Delta factors (change of explanatory variables in time) on the right hand side of the equation in the beginning. It is later

[6] Siqi Zheng, Matthew E. Kahn, 2007. *Land and residential property markets in a booming economy: New evidence from Beijing.* Journal of Urban Economics.
[7] Karl E. Case, Christopher J. Mayer, 1996. *Housing price dynamics within a metropolitan area.* Regional Science and Urban Economics 26 (1996) 387-407.

found that in fast growing city like Chengdu, with relatively short time window to be studied, the initial and inherent locational specific features (level factors) are more important affecting unit price movement.

More recent research developed the topic about the nature and variation in cross-section housing price dynamics by including factors such as (1) Urban economics (2) Race (3) Demographics and Household Income (4) Geographic feature. Yet the studies did not test price movement in time series. Part of reason is probably city's economic and demographic conditions don't change much in short-time span in developed countries. China, on the contrary, is experiencing rapid urban transformation and economic growth, accompanied with substantial demographic restructuring in a relative short-time frame. The magnitude and speed of such movements could have significant impact on the volatility of housing price. For example, research on the impact of economic restructuring and urban growth on spatial dynamics of the Hong Kong housing market, 1992-2008 by Monkkonen, Wong and Begley (2011)[8] had studied determinants of housing price dynamics in time series at neighborhood level. The research took consideration of both economic indicators and social demographic composition. It found that aside from locational features, economic factors such as initial prices and speculative investment are also significant determinants of neighborhood housing price changes. The authors identified that in sub-periods capitalization effects of the determinants varied. They also found that economic geographic transformation with corresponding employment redistributions, urban growth with infrastructure improvement and population decentralization through new town construction in the urban periphery can explain why the degree of significance of the determinants differs in

[8] Paavo Monkkonen, Kelvin Wong, Jaclene Begley, 2011. *Economic restructuring, urban growth, and short-term trading: The spatial dynamics of the Hong Kong housing market, 1992–2008.* Regional Science and Urban Economics 42 (2012) 396–406.

sub-periods. The article leads the way integrating physical and locational characteristics with economic underlying to interpret housing price difference cross-section and price movement in time.

This paper adopts methodology from the above researches and takes into consideration of characteristic situations in China. In specific, both the quantitative analysis and qualitative discussion will be at street-block level, an equivalence of neighborhood in Hong Kong paper. Both housing unit price variation cross section and its change in time are studied. Field interviews provide non-quantifiable explanations to supplement models. Physical attributes of units, Distance to locational features and public goods, Economic and demographic indicators, and a few dummy variables are studied integrally. The objective is to explain the features' various degree of capitalization in housing prices cross 75 street blocks and their distinctive roles in moving prices in time.

Chapter 2. The Chengdu Housing Market

2.1 Characteristics of City

Chengdu is the important provincial capital of Sichuan Province in Southwest China. The urban area houses over 14million inhabitants, more than half within nine municipal districts, five of which consists of 75 street blocks of the research. Chengdu is a hub in China's western regions for commerce, finance, transportation, communications, advanced technology, manufacturing, modern agriculture and logistics. According to the 2007 Public Appraisal for Best Chinese Cities for Investment, Chengdu was elected, among total 280 urban centers in China, as one of top ten cities to invest.[9] In a report by the Nobel economics laureate, Dr. Robert Mundell and the celebrated Chinese economist, Li Yining, released by the China National Information Center in 2010, Chengdu has become an "engine" of the national Go West Initiative, a benchmark city for investment environment in inland China, and a major leader in new urbanization approaches.[10] In October 2010, Forbes magazine released a list of the world's fastest-growing cities, and Chengdu was one of four Chinese cities on the list.[11] The city was recently named China's 4th-most livable city by China Daily. Figure 5 and 6 present some preliminary information about the city and the five focused administrative districts.

[9] Source: Chinanews, Sichuan Sector.http://www.sc.chinanews.com.cn/news/2012/0410/020598821.html
[10] Source: China Daily. http://www.chinadaily.com.cn/cndy/2012-05/28/content_15398560.htm
[11] Source: Global Times Forum. http://forum.globaltimes.cn/forum/showthread.php?p=50487

Nickname(s): 蓉城 (The Hibiscus City)

Location of Chengdu City (yellow) in Sichuan province and the PRC

Location in China

Coordinates: 30°39′49″N 104°04′00″E

Country	People's Republic of China
Province	Sichuan
Established	311 BC
City seat	Qingyang District
Divisions	
- County-level	9 districts, 4 county-level cities, 6 counties
Government	
• Type	Sub-provincial city
• CPC Party Chief	Huang Xinchu (黄新初)
• Mayor	Ge Honglin (葛红林)
Area	
• Sub-provincial city	12,132 km^2 (4,684 sq mi)
• Urban	2,129 km^2 (822 sq mi)
• Metro	1,617 km^2 (624 sq mi)
Elevation	500 m (1,600 ft)
Highest elevation	5,364 m (17,598 ft)
Lowest elevation	378 m (1,240 ft)
Population (2010)[1]	
• Sub-provincial city	14,047,625
• Density	1,200/km^2 (3,000/sq mi)
• Urban	7,677,100
• Urban density	3,600/km^2 (9,300/sq mi)
• Metro	6,730,749
• Metro density	4,200/km^2 (11,000/sq mi)
• Major Nationalities	Han
Time zone	China Standard (UTC+8)
Postal code	**610**000-**611**44
Area code(s)	28
GDP (nominal) Total (2010)	¥ 555.13 billion (US$82.119 billion)
GDP (nominal) Per Capita (2010)	¥ 43,417 (US$6,442)
License Plate Prefix	川A 川O (Government)
Website	http://www.chengdu.gov.cn

Figure 5. Chengdu, Sichuan Province China[12]

[12] Source: http://en.wikipedia.org/wiki/Chengdu

Administrative Divisions

Chengdu is a sub-provincial city. It has direct jurisdiction over 9 districts (区 *qu*), 4 county-level cities (市 *shi*) and 6 counties (县*xian*) :

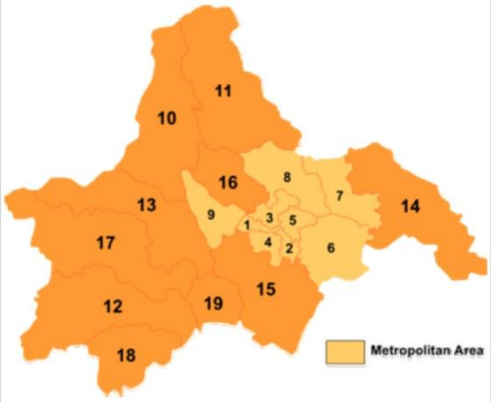
Map	#	Name	Hanzi	Hanyu Pinyin	Population (2010)[1]	Area (km²)	Density (/km²)
	**City Core**						
	1	Qingyang District	青羊区	Qīngyáng Qū	828,140	66	12,548
	2	Jinjiang District	锦江区	Jǐnjiāng Qū	690,422	61	11,318
	3	Jinniu District	金牛区	Jīnniú Qū	1,200,776	108	11,118
	4	Wuhou District	武侯区	Wǔhóu Qū	1,083,806	77	14,075
	5	Chenghua District	成华区	Chénghuá Qū	938,785	109	8,613
	Suburban districts within city limit						
	6	Longquanyi District	龙泉驿区	Lóngquányì Qū	767,203	558	1,375
	7	Qingbaijiang District	青白江区	Qīngbáijiāng Qū	381,792	392	974
	8	Xindu District	新都区	Xīndū Qū	775,703	481	1,613
	9	Wenjiang District	温江区	Wēnjiāng Qū	457,070	277	1,650
	Satellite cities						
	10	Dujiangyan	都江堰市	Dūjiāngyàn Shì	657,996	1,208	545
	11	Pengzhou	彭州市	Péngzhōu Shì	762,887	1,420	537
	12	Qionglai	邛崃市	Qiónglái Shì	612,753	1,384	443
	13	Chongzhou	崇州市	Chóngzhōu Shì	661,120	1,090	607
	Rural						
	14	Jintang County	金堂县	Jīntáng Xiàn	717,225	1,156	620
	15	Shuangliu County	双流县	Shuāngliú Xiàn	1,158,516	1,067	1,086
	16	Pi County	郫县	Pí Xiàn	756,047	438	1,726
	17	Dayi County	大邑县	Dàyì Xiàn	502,198	1,327	378
	18	Pujiang County	蒲江县	Pújiāng Xiàn	239,562	583	411
	19	Xinjin County	新津县	Xīnjīn Xiàn	302,199	330	916

Figure 6. Administrative Districts, Chengdu[13]

In 2011, the city reported a GDP of 685.46 billion yuan, increasing 23.5 percent from the previous year and 6 percentage points higher than the national average rate. Between 2006 and 2011, the GDP has a compounded annual growth rate of 19.8 percent, equivalent to 2.5 folds of economic growth in five years. Looking at industrial restructuring, ratio of primary industry to total GDP dropped from 8.2 percent in 2006 to 5.9 percent in 2011, whereas ratio of secondary industry to total GDP is 45.08 percent and the number of service industry is 48.16 percent, with small change in five years.[14] The secondary and service industries, which include food, medicine, machinery, manufacturing, service and information technology, become economic pillars of the city, far more important than the primary industry.

[13] Source: http://en.wikipedia.org/wiki/Chengdu

[14] Source: Chengdu Yearbooks, local municipal bureau of statistics. www.cdstats.chengdu.gov.cn

Since 2005 Chengdu initiated critical movements to reorganize economic geography and restructure industrial structure. A few specially designated industrial zones, mostly for upgraded secondary industry, are established along the urban periphery, especially south. Two important special economic zones on south, the already established Chengdu Hi-Tech Industrial Development Zone, size of 82.5 km^2 and the on-going Chengdu Tianfu Zone, size of 1,578 km^2 are no long single purpose economic district. They are integrated urban functions composed of modernized industry, producing and service, residence and commerce. These actions gradually move secondary industry out of the core of city, generally defined within the 3rd ring road. The two special economic zones on south, especially Tianfu Zone begin to form secondary city center. Service industry, led by Financial/Insurance/Real Estate is encouraged to form in the core of city. For agglomeration economies, these sectors choose to stay together at place equipped with well-developed public amenities and convenient infrastructures. In Chengdu, a classic monocentric city, these sectors concentrate at inner city, generally defined within the 2nd ring road, and spread along North-South orientated subway line1, which has been in operation since 2010.

The industrial restructuring and the relocation of internal economy geometry has changed geographic employment map. The corresponding effects on housing are not without importance. Population starts to decentralize and move to where jobs are, especially to new economic zones along peripheries of the city. In Chengdu, a classic monocentric city, its social goods undersupplied and unevenly concentrated at the core of city. The development of city's transportation and infrastructure is behind the rapid urban growth, and again located unevenly. People who work in FIRE sectors in inner city, though paid better relatively, may have to either

pay a lot to live closer to the job or suffer long commute time in order to live more comfortably at outside 3rd ring road. According to 2010 Household Survey in Chines Cities and Towns, the ownership rate of private car in Chengdu ranks No.5 among 36 major cities. One-way commuting time is averagely 28.4 minutes, longer than most cities in America and Europe (US Census Bureau, 2005; King and Leibling, 2003).[15]

Population in-flow from rural to city is another important characteristic in the past decade. Between 5th (in Year2000) to 6th (in Year2010) national population census, data show that Chengdu's urbanization is accelerated. In 2010 residents living inside the city consist of 65.21 percent of the total population, 12.03 percent higher than ten years ago.[16] Employments also grow quickly. By the end of 2010, annual growth of employment is 267.5K in five years. Employees in nine administrative districts are 57.6 percent of the city's totality, 12.9 percent raise in five years.[17] The rise of population and the increase of migrant's in-flow to the core of city result in larger housing demand. It is noticed that unlike housing in Northern America cities where single family home is predominant, most housing units in Chinese cities are in multi-unit buildings. Classifications of residential building based on height are (1) Low-rise (below 6 stores) (2) Multiple-story (7-11) (3) Middle-rise (12-17 stores), (4) High-rise (18-32Fls) and (5) Super-high tower (above 100m). Although such living pattern decides that the difference in the amount of land used by different income group is not large, the fast-growing population concentrated in the core of city still generates high pressure on land and housing supplies.

[15] Source: *Spatial Relationship Analysis of City Dynamic Based "Housing-Jobs"- Study Using The Core of City Chengdu As Example,* by Institute of Real Estate Studies, Tsinghua University, Nov.2011
[16] Source: National Bureau of Statistics of China. http://www.stats.gov.cn/tjgb/rkpcgb/
[17] Source: Chengdu Yearbooks, local municipal bureau of statistics. www.cdstats.chengdu.gov.cn

2.2 Monocentric City

Figure 7 displays spatial distributions of geocoded public goods and amenities including core schools (primary, junior/senior high, and university), park, hospital, shopping mall, hotel, civic plaza. Subway Line1 (North-South) and Line2 (NW-SE) are included. The utmost circle is express beltway. 3rd ring road and 2nd ring road are within the beltway. The GIS maps indicate that large amount of social amenities and public goods are concentrated within 3rd ring road. The closer to the core of the city, the denser these amenities are. Figure 8 shows spatial distributions of 5,769 new housing projects (different from individual unit) between 2000 and 2010. The graph again indicates that new projects largely locate within 3rd ring road. To study housing-job relationship, 299 locations of new offices for sale or for rent in 2010, representative of geographic distribution of service industry are exhibited in Figure 9. The density is again increasing as it is closer to CBD. The spread of offices along southern portion of subway line1 indicates that service industry tends to agglomerate at place with convenient transportation. It also proofs that Tianfu New Economic Zone in southern areas begins to form 2nd city center.

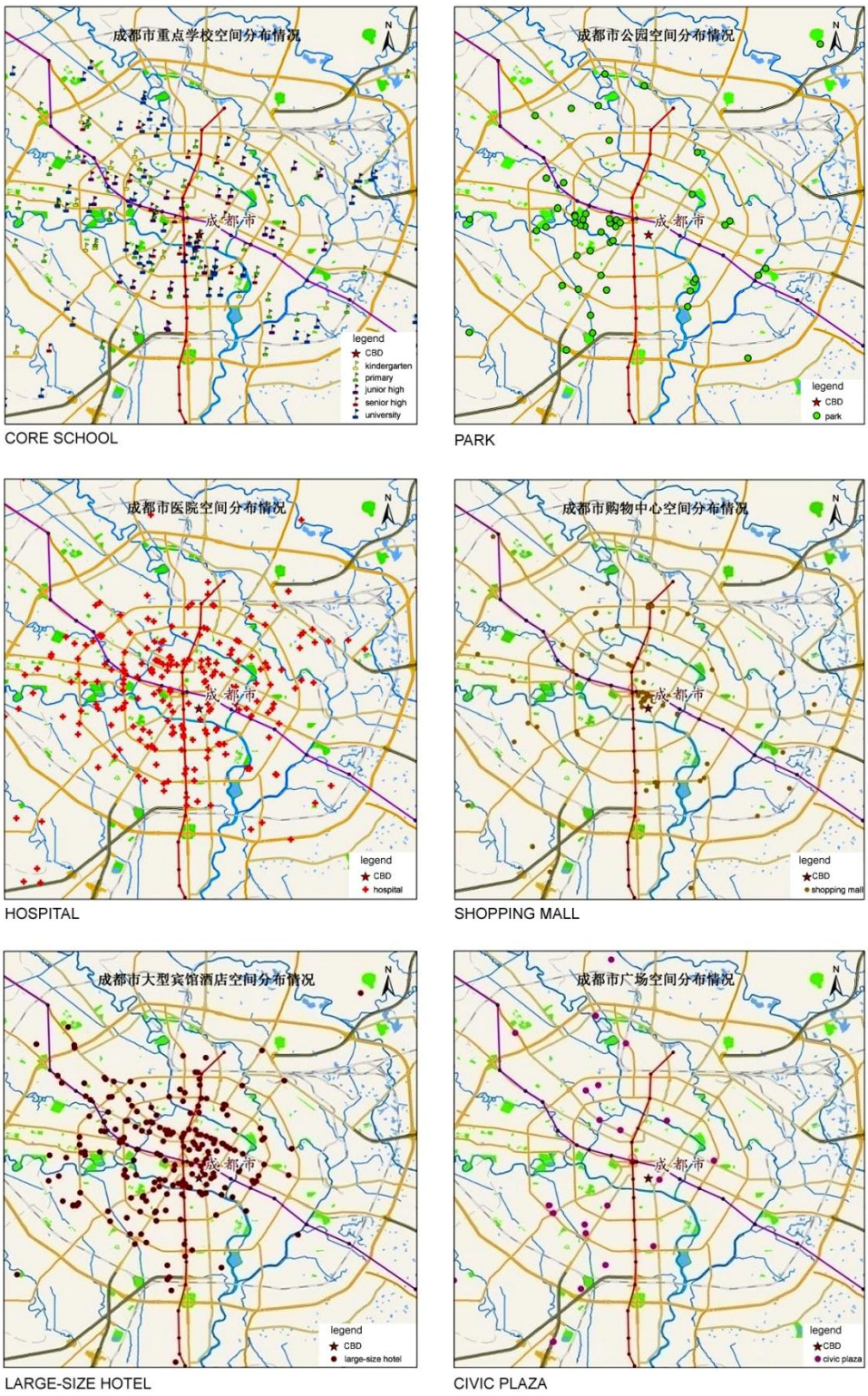


Figure 7. Public Amenities, Chengdu (2010)[18]

[18] Source: *Spatial Relationship Analysis of City Dynamic Based "Housing-Jobs"- Study Using The Core of City Chengdu As Example,* by Institute of Real Estate Studies, Tsinghua University, Nov.2011

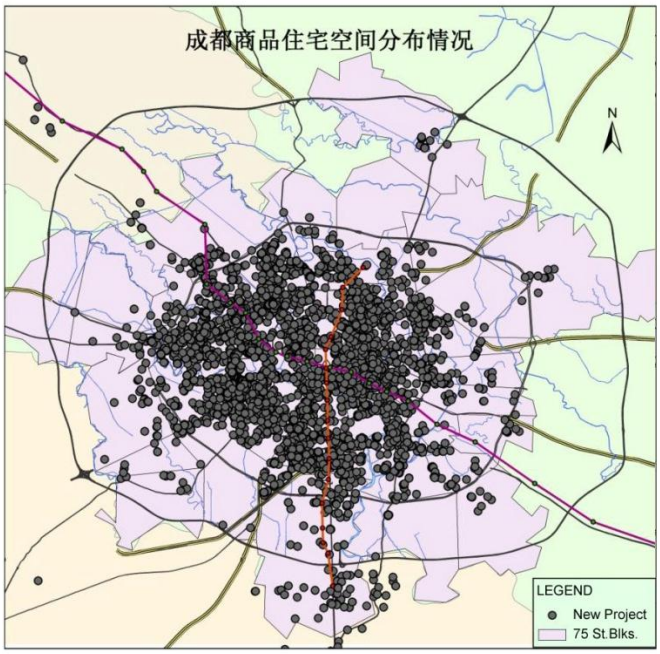


Figure 8. New Housing Projects (5,769 samples), Chengdu (2000-2010)[19]

Figure 9. New Offices (299 samples), Chengdu 2010[20]

[19] Source: *Spatial Relationship Analysis of City Dynamic Based "Housing-Jobs"- Study Using The Core of City Chengdu As Example,* by Institute of Real Estate Studies, Tsinghua University, Nov.2011

[20] Source: *Spatial Relationship Analysis of City Dynamic Based "Housing-Jobs"- Study Using The Core of City Chengdu As Example,* by Institute of Real Estate Studies, Tsinghua University, Nov.2011

Quantitative study of monocentric pattern of Chengdu using simple Ordinary Lease Square regression model is tested to see how the distance to city center is capitalized into housing unit price (Eq.1). The left hand side of the equation is logarithm price of 463,561 transaction samples between 2005 and 2010Q2. Distance to CBD on the right hand side is the only explanatory variable, transaction time controlled by year dummies. CBD is defined by a civic plaza called Tianfu Plaza (differed from the new economic zone in southern periphery), located in the very heart of the city and where the two subways intersect. The simple hedonic model with negative gradient indicates that an extra kilometer away from CBD drops housing unit price by 4.3 percent. A similar test on Beijing yields negative gradient of 2%.[21] In comparison with Beijing, Chengdu has steeper negative gradient of capitalization effect by distance to CBD, evidence that Chengdu is a more single-centered city than Beijing.

$$\underset{(6380.36^{***})\ (-280.42^{***})}{\text{Log (Price)} = 8.432 - 0.043 \times D\_CBD} + \text{Year Dummy} \qquad \text{Eq.1}$$

$(R^2 = 0.392, \quad \text{No.of obs.} = 463{,}561)$

2.3 Separation and Imbalance of Housing-Jobs

Chengdu, a classic monocentric city with rapid economic restructuring and urban growth has serious separation and imbalance between housing and jobs. In the last two years, Professor Zheng led her team from Institute of Real Estate Studies, Tsinghua University to study in great depth the spatial coordination between housing and jobs in Chengdu. The study includes two

[21] Siqi Zheng, 2011. *The Spatial Structure of Urban Economy: Housing, Jobs and Related Urban Issues.* Tsinghua University Press, Beijing China. 42-43

parts: (1) Spatial coordination between housing and service jobs; and (2) Spatial coordination between housing and manufacturing jobs.[22]

The study reveals that the main city center is in a circle of 2km radius centered on Chengdu CBD, defined as where Tianfu plaza is. About 20 percent of service jobs are concentrated here. The secondary city center starts to form on southern city, between 3rd ring road and the express beltway. The formation of it is led by the development of Tianfu New Economic Zone and stimulated by the operation of subway line1 because southern end of line1 is in the zone. Presently, it is estimated that 2nd city center is a circle of 2.5km radius centered on southern end of subway line 1 in Tianfu zone. 15 percent of service jobs are in the area. It is growing towards south. (Fig.10)

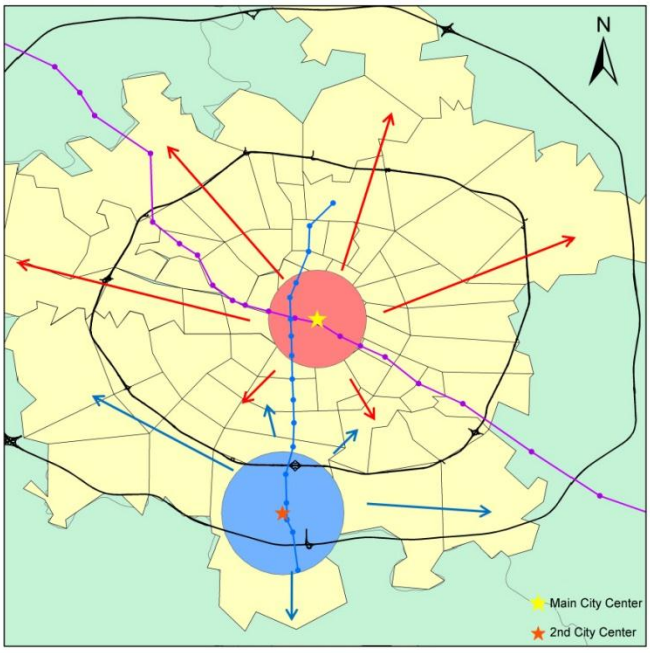


Figure 10. Two Service Job Centers & Their Influences, Chengdu[23]

[22] See *Spatial Relationship Analysis of City Dynamic Based "Housing-Jobs"- Study Using The Core of City Chengdu As Example,* by Institute of Real Estate Studies, Tsinghua University, Nov.2011

[23] Source: *Spatial Relationship Analysis of City Dynamic Based "Housing-Jobs"- Study Using The Core of City Chengdu As Example,* by Institute of Real Estate Studies, Tsinghua University, Nov.2011

Figure 11 presents an overlay of area distributions of service jobs and housing. The colored 75 street blocks comprise the five main administrative districts in the core of city. Saturation of colors indicates various total housing areas (in square meter) in each street block. The calculation uses the same transaction samples (total 513,092), which are sorted into 5,769 housing projects. The cumulative area summation (2005-2010) of all projects that are in one street block is defined as proxy of its total housing areas. Service jobs are represented by the summation of office areas in one street block. The 299 office data from figure 9 are used.

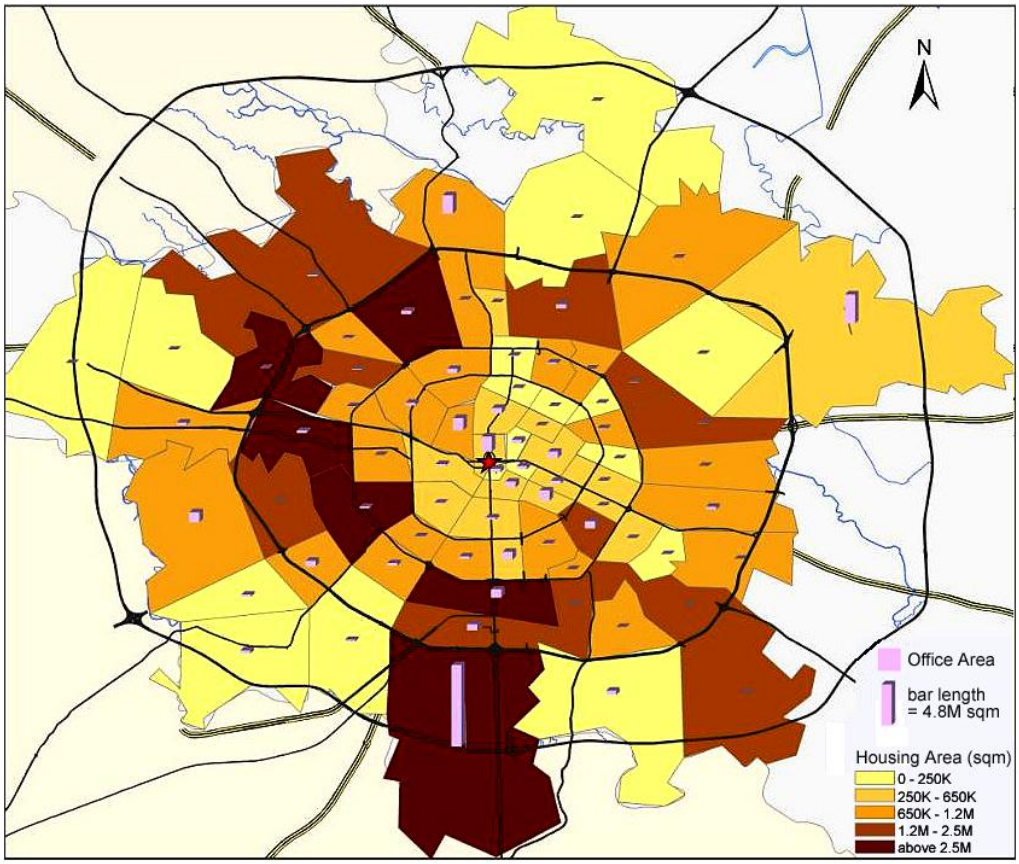


Figure 11. Spatial Distributions of Housing & Service Jobs (sqm), Chengdu 2010[24]

[24] Source: *Spatial Relationship Analysis of City Dynamic Based "Housing-Jobs"- Study Using The Core of City Chengdu As Example,* by Institute of Real Estate Studies, Tsinghua University, Nov.2011

From the graph, it is obvious that spatial distribution of housing and service jobs is separated and imbalanced. Gap between jobs and housing is large in most street blocks. In contrast to Tianfu New Economic Zone on south, where housing-job is relatively balanced (dark colored area with tall bar), donut areas between 2nd and 3rd ring road exhibit serious imbalance between housing and service jobs (be noticed that the utmost circle is express beltway). Within 2nd ring road, summation of office bars comprises 20 percent of total service jobs with a 2km-radius circle from city center, whereas most of dark colored street blocks (more housing areas) are located between 2nd and 3rd ring roads.

To support figure 11, Professor Zheng and her team calculate cumulative housing area distribution from CBD to periphery (Tab.1). Only 5.46 percent of housings areas are in a 2km-radius circle centered on CBD, in contrast to 20 percent of total service jobs in the same geometry circle. The radius has to expand to 4km, an equivalence of 4 times the size of the circle where the 20 percent of service jobs locate, in order to provide 17.60 percent of housing areas. Such calculation is only accounting for ratio balance of housing-jobs without taking consideration of actual job match. If actual match can be measured, it is expected that the housing-area circle has to expand further outward to match the 20 percent of service jobs in the 2km-radius circle in the core of city.

Distance to CBD	Cumulative Housing Area (sqm)	Cumulative Percent
0-2 km	5,194,781	5.46%
0-3 km	10,696,097	11.24%
0-4 km	16,750,188	17.60%
0-5 km	26,750,188	28.11%

Table 1. Cumulative Housing Area (sqm) Distribution and Ratio from CBD, Chengdu 2010

Same calculation is exercised to test how large the radius of housing area circle has to be in order to balance service jobs in 2nd center. As aforementioned, 15 percent of the city's total service jobs are in a circle of 2.5km radius centered on southern end of subway line 1 in Tianfu zone, the emerging 2nd city center. Table 2 shows that only 4.16 percent of housing areas are in the circle. The radius has to expand to 4km, an equivalence of 4 times the size of the circle where the 15 percent of service jobs locate, in order to provide 14.65 percent of housing areas.

Distance to 2nd City Center	Cumulative Housing Area (sqm)	Cumulative Percent
0-2.5 km	5,015,781	5.27%
0-4 km	13,935,936	14.65%
0-5 km	18,063,424	18.98%
0-6 km	18,550,924	19.50%

Table 2. Cumulative Housing Area (sqm) Distribution and Ratio from 2nd Center, Chengdu 2010

To further manifest the point, Professor Zheng and her team studied Housing-Service Job Gini factor. Consistently with Figure 11, housing area per street block is represented by total housing project areas in one street block cumulated from 2005 to 2010. Service job is represented by total cumulative office areas in the corresponding street block. Shadow area (Fig.12) indicates the difference between housing and service jobs. The housing-service job Gini factor is the ratio of the shadow area, labeled as "A", over the triangular area. The result is 0.646. Same Gini factor in Beijing is 0.567. The result manifests that housing-service job imbalance in Chengdu is more serious than it is in Beijing. Where jobs are abundant the housing is relatively undersupplied, vice versa. The separation and imbalance between housing and service job results in longer commute time and inefficient allocation of public resources. Subsequently,

distance to where service jobs are, either CBD or 2nd city center, and distance to transportation (subway station) will be significantly capitalized into housing price.

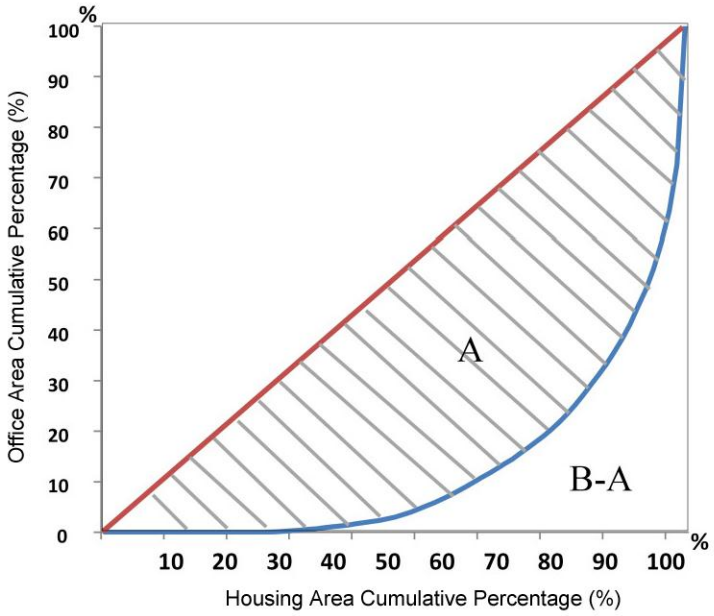


Figure 12. Housing-Service Job Gini Curve[25]

Same analysis on separation and imbalance of housing-manufacturing job is studied by Professor Zheng and her team. The result reveals more serious imbalance. Its Gini factor is 0.696, higher than housing-service job. It is probably because manufacturing jobs are relocated from the core of city to NW and SW of the periphery, where housing doesn't follow to be developed in nearby areas. When housings are mostly circularly distributed between 2nd and 3rd ring road, manufacturing jobs are at NW and SW peripheries outside 3rd ring road, average commute distance between housing and manufacturing jobs are longer than it is between housing and service jobs.

[25] Source: *Spatial Relationship Analysis of City Dynamic Based "Housing-Jobs"- Study Using The Core of City Chengdu As Example,* by Institute of Real Estate Studies, Tsinghua University, Nov.2011

In general, Chengdu remains a classic monocentric city with serious house-job separation and imbalance. The industrial upgrade and economic restructuring reorganized the internal economic geography. 2nd industry is relocated from city center to NW and SW periphery. Service industry agglomerates at inner city to form main city center. Second city center is gradually established in Tianfu Zone on southern city, where southern end of subway line1 and South Train Station are. Due to land scarcity, land policy and historic reasons, inner city (area within 1st ring road) has very limited housing supply. Most new housing projects are distributed circularly between 2nd and 3rd ring road. Although economic agglomeration is beneficial to industries, housing-job separation increases household cost, both monetary and time. Long commute time and overloaded public transportation reduce both individual and the city's efficiency. Therefore, factors that increase housing-job balance and efficiency will become critical considerations by household when selecting place to live. Consequently these factors are significantly capitalized into housing price.

2.4 Political Economy

In China, capital market is constantly monitored and interfered by the central government. Property market is no exception. Real Estate industry accounts for 10 percent of annual GDP growth. 40 percent of GDP's annual growth comes from industries pertinent to property development.[26] The central government often enforces supportive policies to stimulate real estate industry when other industries are at their difficulties. Conversely, tightening measures are applied when the economy is overheated and speculative investment is smelt. Thus it is no

[26] Source: National Bureau of Statistics of China. http://www.stats.gov.cn/tjgb/rkpcgb/

surprise that part of volatility of property market is the result of policy interference from the central government in the past years.

Property market intervention by central government can be generalized into three types: (1) tax and monetary policies applied on mortgage and loan; (2) regulatory control over demand side, and (3) regulatory control over supply side. Tax and monetary policies from central bank to apply on mortgage and loan involve: (i) rate and schedule to pay stamp duty and value added land appreciation tax (ii) rate, schedule of issuance, and ratio of development project loan over property value (iii) mortgage rate and percentage of down payment to 1st and 2nd purchasing, and whether mortgage available to 3rd and more units purchasing (iv) pilot implementation of property tax (v) capital gain tax. Regulatory control over demand side includes: (i) whether to allow non-local purchasing (ii) whether to allow multi-units purchasing (iii) minimum holding period before resale of housing unit without incurrence of business tax. Regulatory control over supply includes: (i) whether to allow certain housing types, such as single family house to be included in the project (ii) requirement of minimum percent of certain size of housing units, such as requirement of minimum 70 percent of units must be smaller than 90sqm (iii) land payment schedule imposed upon developers (iv) allowable holding period of time for idle projects. The following lists key policies implemented by central government between 2007 and 2010.[27]

[27] Ashvin Ahuja, Lillian Cheung, Gaofeng Han, Nathan Porter, and Wenlang Zhang, 2010. *Are House Prices Rising Too Fast in China?* IMF Working Paper, Asia and Pacific Department, December 2010.

SELECTED REAL ESTATE MEASURES IN CHINA
Property Market Related Policies in Mainland China (2007-2010)

Tightening measures

Jan 2007	Impose value-added taxes on land transactions.
Sep-2007	Raise the minimum down payment ratio to 40 percent and the minimum mortgage rate to 110 percent of the benchmark rate for second mortgage.
	Minimum down payment ratio and mortgage rates are higher for third mortgage loans.
Apr-2008	Impose tax on capital gains on advanced payments of housing purchases.
Jun-2008	Impose personal income taxes on corporate purchasing properties for individuals.
Aug-2008	Forbid loans for land purchases and for idle projects.

Supportive policies

Oct-2008	Waive stamp duty on housing transactions and value added taxes on land transactions.
	Lower the minimum mortgages rate to 70 percent of the benchmark rate and the down-payment ratio to 20 percent.
Dec-2008	Extend preferential policies for first home purchases to second home purchases.
	Shorten the housing holding period to enjoy business tax exemption from 5 years to 2 years.
May-2009	Reduce developers' capital requirement for economic and commodity housing investment to 20 percent.

Tightening measures

Dec-2009	Extend the housing holding period to enjoy business tax exemption from 2 years to 5 years.
	Require developers to pay at least 50 percent as the initial payment for land purchase.
Jan-2010	Set minimum down-payment ratio for the second mortgages at 40 percent.
Apr-2010	Raise minimum down-payment ratio for the first mortgage to 30 percent for a residential property no more than 90 square meters.

Raise the down-payment ratio for the second mortgage to 50 percent, and the minimum rate to 110 percent of the benchmark rate.

The down-payment ratio and minimum mortgage rate for the third mortgage and above will be much higher.

Restrict mortgage lending to non-residents

Increase land supply for residential properties.

Two classes of policy intervention, regulatory control over demand and regulatory control over supply have strong impact on housing price inside a city like Chengdu. The field trip and interview during the thesis development received comments and inputs from local market experts. They highlight the importance of policy intervention on geographic sub-markets cross street blocks. For example, tighten policy in April 2010 prohibit certain type of housing units (luxury single family house) from being built and forcefully request minimum 70 percent of total housing units be ones less than 90sqm in a development project. The policy casts serious impact on locations where luxury single family house is major product. Usually these locations either have unique natural resources such as beautiful mountain and large body of water, or can provide special locational amenities. They are exclusively suitable for large size luxury housing product.

When developers are requested not to build suitable product but other types such as small size units in certain area, they can't sell small size unit at the same unit price as luxury single family house. They have to build large amount of small units in the hope that total sale with low unit price can still be profitable. Hence this policy can bring down unit price of some street blocks which were selling luxury unit with high unit price before. It has minor impact on street blocks which already have been building small units as majority. On the other hand supportive policy

such as the allowance of multiple-unit purchasing can stimulate unit price in some locations which have stock of units that are best suitable for speculative investment.

In China, policy intervention from central government alternates from time to time without necessarily following reasonable economic rules, developers can only choose to do what they think are most suitable to do, in most case is keeping building. Housing price can be volatile cross section when certain geographic sub-market is more affected by the policy than others. Although policy intervention is difficult to anticipate and to quantify, it is necessary to account for it as key determinant of housing price difference cross section and price movement in time.

Chapter 3. Data Introduction

The quantitative analyses explore two questions: Why unit price is different cross section and Why unit price movement is different in time? Three groups of explanatory variables are studied: physical attributes of housing unit, locational features and public goods of the street block where the unit locates, and the street block's economic/demographic characteristics. Two hedonic models, Level Model and Change Model are tested to explore determinants of unit price difference cross sections and unit price movement in time between 2005 and 2010. Further refined subgroup models based upon unit size are studied at both Level and Change status. Three approaches to measure unit price per street block are adopted as dependent variable in regression model. Field trip and interview is taken in the middle of quantitative analyses. Discussion with local market experts is reviewed by Professor Zheng and the team. Inputs and improvements are incorporated into models to look for more in-depth and breadth results.

3.1 Descriptive Analysis of Measurements of Street-Block Unit Price

A transaction dataset drawn from Chengdu's Housing Administration Department is acquired by Professor Zheng and her team from Institute of Real Estate Studies, Tsinghua University. The dataset contains 513,092 transaction samples between 2005Q1 and 2010Q4. All transactions occur inside the core of the city consisted of five administrative districts: Jinjiang District, Qingyang District, Jinniu District, Wuhou District and Chenghua District.(see Fig.6) The dataset has been cleaned to remove flawed and unqualified samples. For example, housing unit officially registered as under the category of VILLA (luxury single family house) is removed.

Transaction has to occur within four years since the sales begin in the project, which the unit belongs to. The study of the thesis is not built upon actual transaction sample dataset but on street block level. Clearly the smaller the prototype of a street block is, the more accurate the quantitative result would be. Correspondingly smaller size of individual street block request more detailed data information on the right hand side of the model. The concept "street block" is equivalent to the definition of "Area with similar supply and demand". Ideally street block should contain housing units of similar unit price, housing type, building structure, zoning regulation and should be provided with comparable public goods and amenities. Thus spatial characteristics of units in one street block can be considered homogeneous and interchangeable.

The definition of street block in the thesis uses the same one applied in Chengdu Population Census and Economy Census. Figure 13 exhibits 75 street blocks, three ring roads and the outmost express beltway. The centroid of the street block is defined as where the neighborhood's administrative office locates. The largest street block is 34 square kilometer whereas the smallest one is only 0.25 square kilometer. The further distance away from city center, the larger the street block becomes. Different street block size is only determined by its geographic location and has no effect on study.

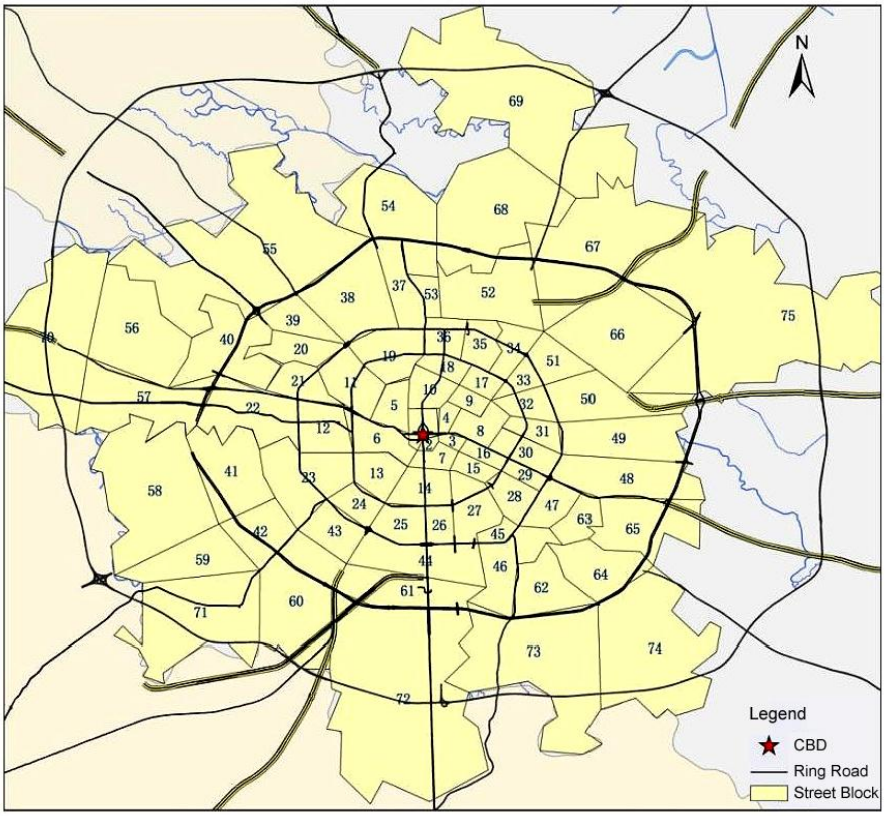


Figure 13. 75 Street Blocks, Chengdu[28]

For unit price on the left hand side of the models, three approaches are taken to measure it as street block level. Project Mean is used for both Level Model and Change Model prior to field trip. Unit Mean and Unit Median are tested as alternatives incorporating comments from local market experts.

Definition 1: Project Mean (RMB per sqm) of Street Block in year T (2005-2010)

$$Price^{Yr(T)}_{(project\ mean)} = \text{Mean of} \sum_{k=1}^{n} \text{Mean of transaction units in project(k) in year T}$$

(n=number of projects in one street block in year T, T=2005, 2006... 2010)

[28] Source: *Spatial Relationship Analysis of City Dynamic Based "Housing-Jobs"- Study Using The Core of City Chengdu As Example,* by Institute of Real Estate Studies, Tsinghua University, Nov.2011

In this calculation, two steps of averaging are taken at project level and street block level respectively. First average unit price (RMB per sqm) of one project in year T is calculated by averaging unit prices of all the transacted units in the project in year T. Next, average unit price of one street block in year T is calculated by averaging unit price of all projects in the street block in year T.

Definition 2: Unit Mean (RMB per sqm) of Street Block in year T (2005-2010)

$$Price_{(unit\ mean)}^{Yr(T)} = \text{Mean of all transaction units in one street block in year T}$$

(T=2005, 2006... 2010)

Definition 3: Unit Median (RMB per sqm) of Street Block in year T (2005-2010)

$$Price_{(unit\ median)}^{Yr(T)} = \text{Median of all transaction units in a one street block in year T}$$

(T=2005, 2006... 2010)

The unit price per street block is measured in temporal series. Because of data constraint, the total numbers of samples of unit price per street block in 6 years (2005-2010) are not 450 (75x6) but 416.

3.2 Descriptive Analysis of Physical Characteristics

Three physical attributes of housing units are used in hedonic model: (1) average floor at which the transacted units locate, a proxy of average building height in the street block in one specific year; (2) average size of units (Logarithm), and (3) average size of project to which the transacted units belong, a proxy of development density in the street block in one specific year. Corresponding to Definition2 and Definition3 in previous, these physical explanatory variables

are also measured by Unit Mean or Unit Median accordingly. The Unit Mean is used when dependent variable on the left hand side is Project Mean in Definition1.

Other physical attributes not used with data availability include unit age (controlled in four years when cleaning individual transaction sample), FAR, height of building (total floors) where the unit belongs to, whether the unit is furnished and whether the developer is a state owned enterprise, etc. These factors are excluded because they are either not directly related to cross-space housing price difference or they share colinearity with the three selected variables. Physical attributes that are capitalized into housing price intuitively without solid data are unit orientation (whether south facing) and whether unit is through with both north and south exposures.

3.3 Descriptive Analysis of Locational Amenities and Public Goods

The underlying ArchGIS map is provided by Geographic Sciences and Natural Resources Institute, Chinese Academy of Sciences. CBD is defined by a civic plaza called Tianfu Plaza (differed from the new economic zone in southern periphery), located in the very heart of the city and where the two subways intersect. Locational features identified in GIP map includes: 17 stops of subway line1 (in operation since end of 2010), 25 stops of subway line2 (to be operated in 2012), 124 core primary school, core junior/senior high schools and core universities, 98 shopping malls, 230 middle to upper level hotels, 680 sports and entertainment facilities, rivers, lakes, inter-city roads and railroads. (Fig.7)

Homeowners in most Chinese cities do not pay housing property tax. Transportation infrastructure and urban amenities, such as subways, parks and schools, are financed either by the central or local government. Local amenity capitalization effects are expected to be more visible in most Chinese cities than in cities with property taxes because Chinese developers or buyers implicitly purchase those public goods by purchasing land parcels or housing units.[29]

Considering Chengdu as a classic monocentric city with limited locational amenities concentrated in the core of city, six locational variables are selected: Distance to CBD, Distance to subway (logarithm), Distance to core primary school (logarithm), Distance to park (logarithm), Distance to shopping mall (logarithm), and Distance to river (logarithm). Distance is measured from the centroid of street block, where the neighborhood administrative office is, to destination of public amenity. Similar to the reason omitting some physical attributes, locational factors such as lake and entertainment facility are not included because of their multi-colinearity. Distance to core primary school is accounted for but distance to core middle/high school and university are omitted. It is for a couple of reasons. First, according to Chengdu's compulsory education policy, children of household are restricted to enroll in the core primary school of one street block where the household lives. Cross-sectional enrollment of core primary school is not allowed. Such geographic restriction doesn't apply to the enrollment of core junior/senior high school or core universities in Chengdu. Second, core primary schools, comparing to regular ones, are equipped with better resources and possess better track record of sending pupils to core junior/senior high school.

[29] Siqi Zheng, Matthew E. Kahn, 2007. *Land and residential property markets in a booming economy: New evidence from Beijing.* Journal of Urban Economics.

Because of monocentric city, it is expected that all six locational variables should have negative gradients and significant affect to capitalize housing unit price.

3.4 Descriptive Analysis of Economic and Demographic Data

Economic and demographic data are mined from Yearbook and Monthly Report of Local Bureau of Statistics at www.cdstats.chengdu.gov.cn. Data are classified into three groups: demographic, industrial and economic. Data are sorted to five administrative districts in six years (2005-2010). No more detailed data corresponding to street block is available. Street blocks in the same administrative district of the year will share the same set of economic and demographic data. Quality of data is among all the lowest. The data are missing in various categories of measurements and only at district level. Some data only show smooth upward growth without volatility, a typical falsified result. Some data are only available in 2011 not previous years, to artificially make the trend consistent and pleasant. However, the information is to the best available to the public.

After mining and refining data, the following dataset are accepted cross five districts from 2005 to 2010: population density, fixed investment per capita, purchase power per capita, overall gross domestic product (GDP) and broken-down GDP of first, secondary and service industry. Population density and Per capita purchase are classified as demographic characteristics; Overall and broken-down GDP are classified as economic growth and industrial reorganization; and Per capita fixed investment is classified as locational economic growth. All figures are adjusted for inflation against 2004. Important but unavailable data are employment per street block and more

detailed Demographic categories such as population age, household income and household educational background. Given the fact of high population mobilization, hidden income with unofficially paid jobs, these data are very difficult to acquire.

Chapter 4. Models, Interviews, Results and Discussions

Two hedonic models are examined to seek determinants of housing price dynamic as a function of physical attributes, access to various locational features, demographic and economic characteristics. The first model is called Level Model testing determinants of housing price difference cross-section in one year. The second is called Change Model testing determinants of housing price movement in time (2005-2010). This section will firstly focus on Level Model and its preliminary result before the field trip. Then summary of field meeting with local experts are presented. Next, improvement and more reports of Level Model are exhibited. The second part of the section will discuss Change Model and its results.

4.1 Level Model Test and Preliminary Result Before the Field Trip

Level model before the field trip is constructed (Eq.2). The dependent variable is the logarithm of unit price (RMB per sqm) of each street block between 2005 and 2010. Prior to the field trip, project mean unit price in Definition1, section 3.1 is adopted. The other two measurements, Unit Mean and Unit Median are tested after the field trip. Three groups of explanatory variables are on the right hand side of the equation. (1)X_n^P: Physical attributes of units transacted in specific year in one street block; (2)X_n^D: Distance to locational features in specific year in one street block; (3)X_n^E: Economic and demographic characteristics in specific year in one street block. Year dummy is included to control time fixed effect. Table 3 exhibits the preliminary report of Level Model.

Eq.2

$$\mathrm{Log}(P_{(\text{project mean})n}^{PDE}) = \textit{Cons.} + \beta_P * X_n^P + \beta_D * X_n^D + \beta_E * X_n^E + \textit{Year Dummy} + \varepsilon_{\text{residual}} \quad (n=1, 2 \ldots 75)$$

$Log(P_{project\ mean})$ = Definition1, Section 3.1
Determinants of cross-section price dynamics (2005-2010)

	(1) $Log(P^{before\ trip}_{project\ mean})$
P_FLOOR	0.00470
(mean of floors the units locate)	(1.41)
Log(P_HSIZE)	0.0730*
(mean of sizes of units, in sqm)	(1.69)
Log(P_PSIZE)	0.0280
(mean of sizes of projects, in 000 units)	(1.45)
D_CBD	-0.0212***
(in km)	(-4.04)
LOG(D_SUBWAY)	-0.00730
(in km)	(-0.58)
LOG(D_PRIMARY)	-0.0266**
(in km)	(-2.16)
LOG(D_MALL)	-0.0365**
(in km)	(-2.57)
LOG(D_RIVER)	-0.0273**
(in km)	(-2.29)
LOG(D_PARK)	-0.00400
(in km)	(-0.24)
E_3rdRATIO	0.122
(GDP of tertiary industry over total GDP)	(0.45)
LOG(E_POPDEN)	0.247***
(in pop/kilo square meter)	(2.61)
LOG(E_PURCHASE)	0.722***
(in RMB per capita)	(2.83)
LOG(E_FIXEDINVEST)	0.137***
(in 100million RMB per capita, flow)	(3.08)
Year Fixed Effect	Yes
Constant	4.271***
	(2.72)
No. of Obs.	372
R^2	0.693

t statistics in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3. Level Model – Project Mean as Unit Price (prior to the field trip)

The preliminary result is consistent with local market preference and the city's monocentric characteristic. Among three physical attributes, Floor at which the unit is, Unit Size and Project

Size, only Unit Size is moderately significant with positive gradient. The coefficient of Unit Size indicates that a 10% increase in average unit size in a street block increases average unit price 0.73%. It is consistent with local market preference for large size unit which is presently undersupplied. The supply shortage is due to various reasons including the aforementioned regulatory control simply called 70/90 (70% of units in a new development project must be smaller than 90sqm)(Refer to Section 2.3). The other two physical attributes are positively significant when tested at micro transaction sample level using actual price of individual unit on the left hand side of the hedonic model. The transaction-sample based hedonic model was created by Professor Zheng and her team.[30] When exercising the Level Model at street block level, the right hand side explanatory variables become average floor and average project size of all transaction samples in one street block in a specific year. These two physical attributes become insignificant. Some may also challenge that only three physical housing attributes are controlled. The argument is that all these units are condominiums that are quite similar in building structure, internal space, decoration, and even age since all transactions are new housing units. It has been pointed out in Section3.2 that two important physical attributes, unit orientation and whether the unit is through might have been intuitively capitalized into housing price. Their data are not available from underlying transaction sample.

The preliminary result of coefficients of locational features highlights the point that Chengdu is a classic monocentric city. All locational features except Distance to Subway and Distance to Park are significant with negative gradients. Distance to CBD is highly regarded by consumers with $p<0.01$. Because social amenities are scarce and concentrated within 2nd ring road, households

[30] Siqi Zheng, 2011. *The Spatial Structure of Urban Economy: Housing, Jobs and Related Urban Issues.* Tsinghua University Press, Beijing China. 95

are willing to pay high premium to live nearby them. Other locational features including Distance to Hotel, Hospital, Core Junior/Senior High School, Inter-cite Highway and Lake are also tested. They are either insignificant or share multi-colinearity with the tested variables. One particular variable, Distance to Subway, when tested in transaction-sample based model, has high significance with negative slope (Fig. 14). The insignificant result at street block level was noticed prior to the field trip. Probable explanation and tentative improvement approach is discussed during the meeting with local market experts. The refined model and results are further studied.

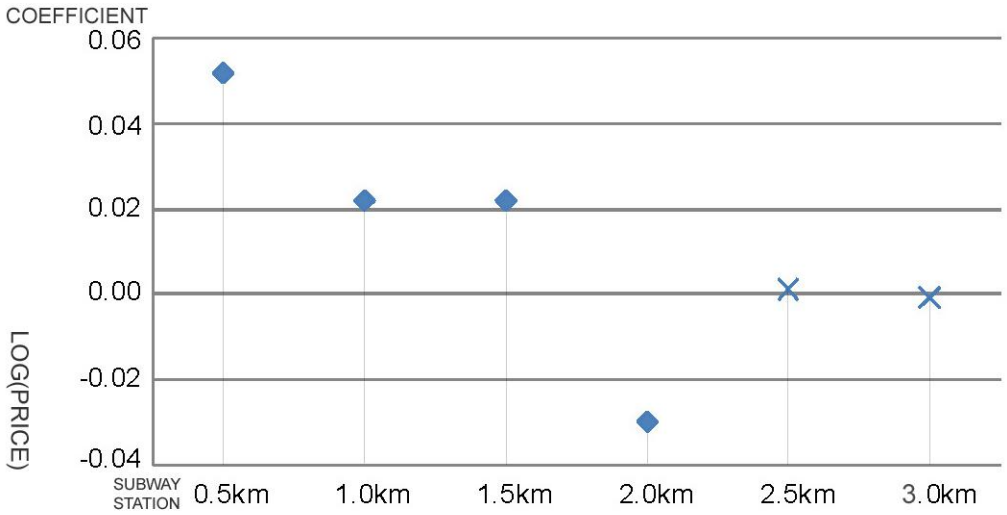


Figure 14. Coefficient of Distance to Subway Station in Log (Price) Model[31]

The preliminary result of economic and demographic variables is encouraging because except for the Ratio of Service Industry GDP over Total GDP, the other three factors are all highly significant with positive gradient. The result indicates that the characteristics of demographic

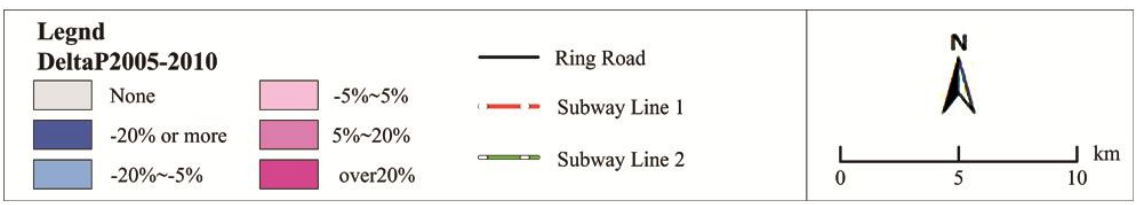
[31] Source: *Construction & Application of GIS Based Spatial Database of New Commercial Housing Transactions - Analysis of Subway Effect & Refinement of "City-Level Housing Price Index"*, by Institute of Real Estate Studies, Tsinghua University, Oct.2010

and economic structure are significant determinants that have been capitalized into the unit price. The coefficient of Population Density variable indicates that the higher the population density is, the higher the demand is. The higher demand subsequently results in larger price premium. The coefficient of Purchase Power Per Capita indicates that a 10% raise of per capita purchase power will yield as high as 7.22% price premium, the highest positive slope among all factors! It indicates that the richer the population in one street block, the higher unit price. Per Capita Fixed Investment is an indicator of infrastructure investment by local government. Here infrastructure is a broad concept including both general infrastructure such as subway, road, bridge, and also real estate. Obviously street block with more per capita investment in infrastructure improves physical environment and creates public amenities in the neighborhood. Households hence are more willing to pay high premium to live there.

4.2 Level Model Discussion During the Field Trip

A field trip is taken during the thesis development. On June 21st, meeting was held in Chengdu office of VANKE, the largest housing developer in China by gross revenue. Attendants are Mr. Zhao, marketing consultant who worked with VANKE prior to starting up his own consulting firm; Mr. Wu, staff of Chengdu Housing Administration Department; and Mr. Wang, staff of VANKE Chengdu office. Mr. Wu holds a Bachelor degree in Mathematics and was involved in joint research between Chengdu Housing Administration Department and Professor Zheng from Institute of Real Estate Studies, Tsinghua University.

Figure 15 was produced to initiate discussion during the meeting. Each of the six GIS diagrams exhibits percentage change of actual average unit price over model predicated average unit price among 75 street blocks between 2005 and 2010. Actual average unit price (Project Mean used for the discussion) is dependent variable on the left hand side of Equation2 in Section 4.1. Model predicated price is the sum of all variables, constant and year dummies on the right hand side of the equation with corresponding inputs. Since we have $\frac{\text{Log}(\text{Price}_{actual})}{\text{Log}(\text{Price}_{model})} = \varepsilon_{residual}$, hence $\frac{\text{Price}_{actual}}{\text{Price}_{model}} = \text{Exp}(\varepsilon_{residual})$. The color in GIS diagram is an indicator of absolute value of (Exp($\varepsilon_{residual}$)-100%). The more saturated Magenta, the higher the actual price is than the model predicated price. The more saturated Blue, the lower the actual price is than the model predicated price. The grey is area that data are unavailable. The maps also display the utmost express beltway, the 3rd ring road within the express beltway. Subway line1 in red, which started operation by end of 2010, and subway line2 in green, which is for operation by end of 2012, are also shown in the maps.



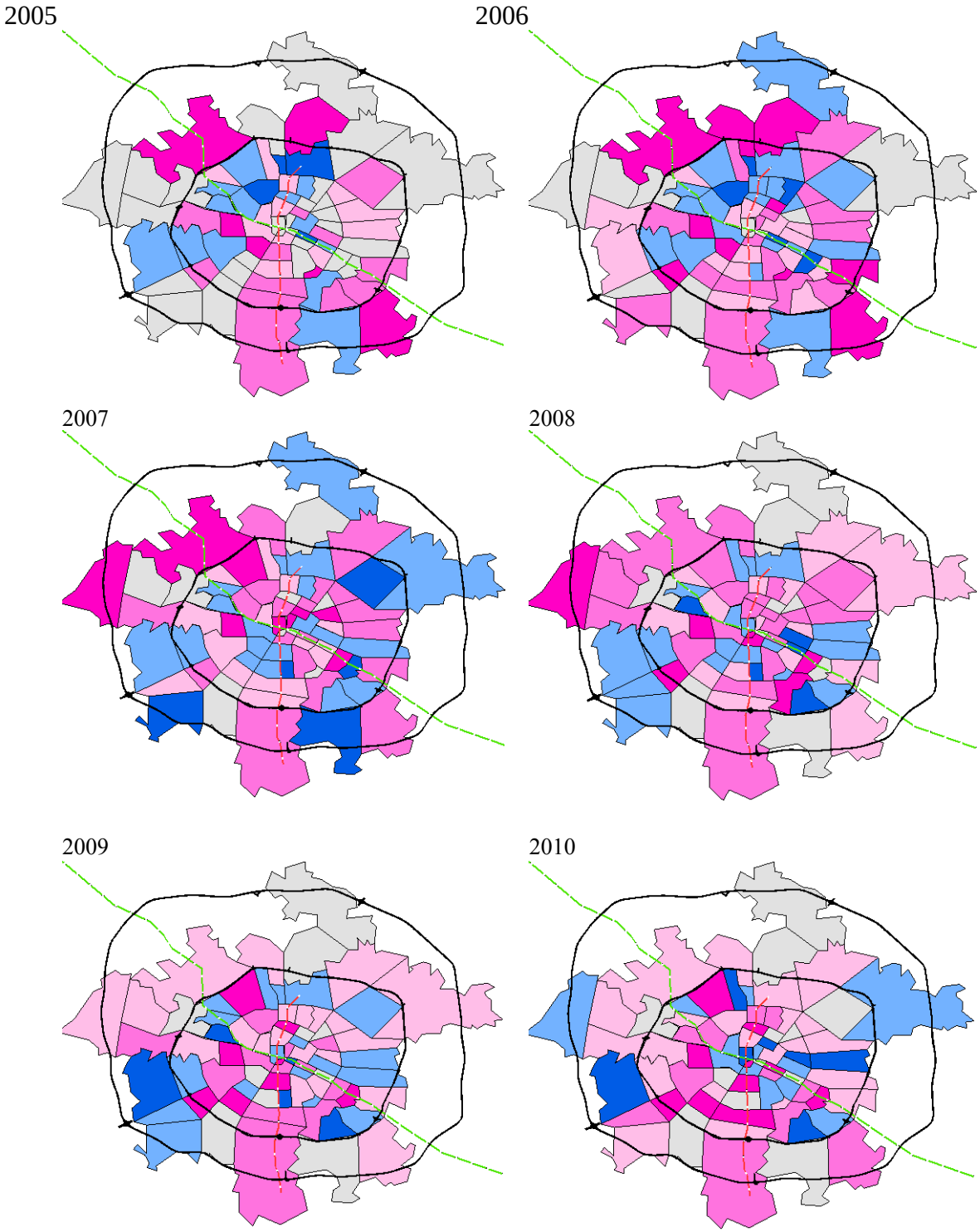


Figure 15. (Exp($\varepsilon_{residual}$)-100%), Actual Price vs. Model Predicted Price, Chengdu 2005-2010

During the field meeting, the beginning topic about GIS diagrams is about the most saturated magenta areas outside of 3rd ring road (the smaller circle within the express beltway) in 2005. According to local experts, it is likely because of certain high-end development projects that result in increased actual unit price in a street block. For example, the street block NW outside of 3rd ring in 2005 is probably because of a popular high-end housing project when no other comparable projects are under construction in nearby street blocks. The logic behind the development of such expensive housing product is probably derived from speculation of special natural resources that the city center doesn't provide. It is believed that such unique locational features will draw rich people to invest as their second home.

The following discussion then reviews color and saturation change of several street blocks outside NW 3rd ring road. Starting with the above studied street block, covered by saturated magenta at NW area in 2005, the magenta begins to grow from 2005 to 2007. In 2008, all five street blocks outside NW 3rd ring road become magenta with the exception of one grey street block (data unavailable). However, in 2008, the magenta color becomes lighter comparing to previous years. In the following two years till 2010, street blocks outside NW 3rd ring road show faded magenta with one street block eventually turned blue. The color changes from 2005 to 2010 tells an interesting story: (1) Between 2005 and 2008, the actual unit price in street block grows higher than model's anticipation, expressed by saturated magenta; (2) Also between 2005 and 2008, the number of street blocks that show higher actual unit price than model price is growing; (3) Between 2008 and 2010, the actual price in these street block moves closer to model's anticipation. In 2010 one street block shows actual price below the model price. The constant grey street block is a national park called Jin Sha (Golden Sand). It is founded recently

in the effort to preserve a 2,000 years' old historic site discovered during a road construction. No development project is then permitted in Jin Sha street block. The housing price movements in these street blocks are driven by a series factors involving all three classifications of explanatory variables: physical attributes, locational features, and economic characteristics. Detailed explanation is as the followings.

As stated above, in year 2005 the rise of unit price in one street block in a specific year is usually stimulated by individual development project(s). Such project is usually driven by unique locational features such as adjacency to national park, mountain or large body of water. Normally luxury housing unit with high unit price is built and sold first in one development project at these locations because the project needs to establish good first impression to lure potential buyers. Luxury unit can be either large in size or in very low building, usually both. The successes of these individual projects draw more developers to these street blocks between 2005 and 2007. The high-end project(s), the luxury unit with high unit price to be firstly sold, and the increased number of developers, all explain the enlarged gap between the increased actual unit price and the model prediction between 2005 and 2007.

In year 2008, such phenomenon reaches its peak with all five street blocks outside NW 3rd ring road becoming magenta. However, closer read reveals that some street blocks' colors become lighter in 2008 than they are in previous year. It indicates that actual unit price begins to move closer toward model's prediction, the gap becoming narrower. Two explanations are provided by local experts. First, after luxury unit are sold out, these projects begin to sell less expensive housing types either small in size or in multi-story condominium. Large amount of less

expensive units sold in 2008 brings down the unit price of the street blocks. The other explanation is that not all developers drawn to the areas are aiming for high-end market. Some of them build cheap units all the time. Hence the average unit price in the area went down as well.

In the following years (2009-2010), the narrower gap between actual price and model price, an indicator of price appreciation slow-down, is interpreted by local experts as joint effects of both policy intervention that prohibits luxury unit from being built, and the city's inclination to develop southern city. Though it is reasonable to argue that Jin Sha National Park stimulates developer to come and build housing units in the place, it later holds infrastructure and economy from growing in the area. The government chooses to protect the national park and slow down urbanization in surrounding areas. In contrast, southern area of the city hosts new municipalities and becomes the secondary city center. The construction and operation of Subway line1, the establishment of Hi-Tech Industrial Development Zone and Tianfu New Economic Zone send clear signals to the market that the emerging focus of the city is not at NW corner but on south.

Two of three people attending the meeting are local. They bring up the fact that historical path, cultural context and perception from local people are all in favor of southern part of the city. Also in a monocentric and fast-growing city like Chengdu, household will value more on public goods and convenient access to job. Natural resources may draw rich people to invest as second or parallel home, they cannot sustain long term price appreciation without picking up the area's infrastructure and economic improvement. As market realizes that street blocks outside NW 3rd

ring road are behind urban development of southern city, and may not be able to catch up in the near future, its willingness to pay high housing price premium diminishes quickly.

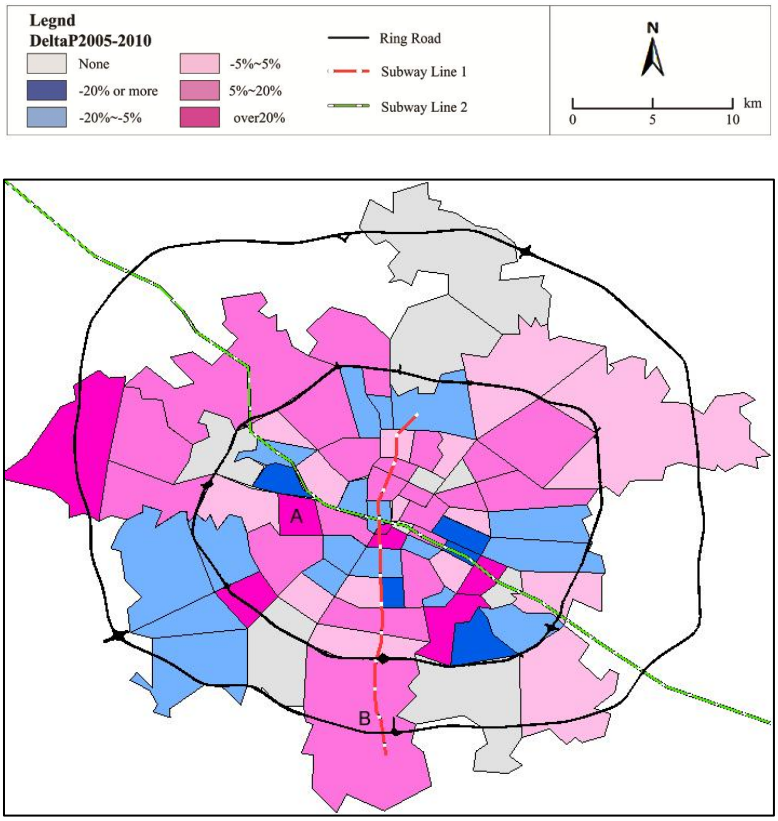


Figure 16. (Exp(Ɛresidual)-100%), Actual Price vs. Model Predicted Price, Chengdu 2008

The second topic about GIS diagrams follows the aforementioned discussion about unevenly developed economics geometry, accompanied by differentiated cultural and historic perception to location. The three experts unanimously point out that two street blocks remain in magenta color cross 6 years. (Fig.16) Street Block A is a street block centered on a famous historic site called Thatched Cottage of Du Fu, a patriotic poet in Tang Dynasty (A.D.618-907). In thousands of years, the area cumulates its fames through countless visitors who come to show respect to the beloved poet. Pocket parks cluster around it in time. Today the neighborhood is

considered the most livable place in the city. It is close to the city center, with good and well-balanced public amenities for diversified activities such as shopping, sports and entertainment, cultural, and schooling. From the perspective of the local, it makes perfect sense that Street Block A keeps high price appreciation no matter how volatile other places are. Street Block B, the southern street block centered on two special economic zones, Hi-Tech Industrial Development Zone and Tianfu New Economic Zone, has been mentioned several times in the thesis. The favored economic policies from local government, the rapidly enhanced infrastructure, the forming of secondary city center with abundant job supplies, and the new municipal administration center all ensure that this emerging hotspot will enjoy housing price appreciation in the foreseeable future. In comparing to Street Block A, which is located in the 2nd ring road with limited land supply, Street Block B is at the periphery of the city growing towards south. Ample land supply probably explains why the magenta color in Street Block B is lighter (actual price moves closer to model price).

The third topic about GIS diagrams comes from the relative more magenta colored street blocks in year 2008 (Fig.16) than any other year. The explanation by local expert comes from the observation that in 2008 local government released more land than it did in previous years. Land parcels were vastly overpriced during bidding process, which resulted in increased housing price. Though the underlying reasons behind the increased land supply and overprice in 2008 were not the focus of the thesis, it is noticed that both global and domestic economy were seriously slowdown in 2008. In order to collect enough fiscal income, it is not surprising that the local government released more land. The large amount of land price premium perhaps was caused by undersupply in previous years. Also the four-trillion RMB stimulus plan with loosened loan

policy by central government in late 2008 encouraged developers, especially State-Owned Enterprises to actively involve in land bidding. Although the in-depth explanation behind the special phenomenon in 2008 deserves further study, it is safe to argue that housing price movement in time is correlated with exogenous economic factors.

The last topic about GIS diagrams touches the base of blue street blocks in 2010. These areas, in which the actual unit price is below the anticipated model price, are in general consistent with the expectation and experience from local experts. They point out that some blue street blocks are in good geographic locations within 2nd ring road. These street blocks don't share high price appreciation probably because the relocation cost is too high. Also because of historic reason, the property ownership of some locations is so complicated that local government is unable to redevelop them. In time, these untouchable parcels become deteriorated patches stuck at the new fabric of the city.

4.3 Level Model Improvement and Result

In addition to GIS graphs, the Level Model is also discussed during the field trip. Comments and improvement suggestions collected during the meeting are further reviewed and discussed with Professor Zheng and her team. The following improvements are taken into consideration..

First, the unit price on the left hand side of the regression model before the trip is measured at project mean level (Definition1, Section 3.1). Another two measurements, Unit Mean and Unit Median are further tested (Definition2&3, Section 3.1). Figure 17 and Table 4 list statistical

information of the three sets of dataset. Unit Mean adds weight at individual transaction level. Unit Mean and Unit Median are compared in case the dataset is not normal distribution.

Variable	Obs	Mean	Std. Dev.	Min	Max
Project Mean (rmb per sqm)	416	4267.4	1492.1	1134.1	10949.1
Unit Mean (rmb per sqm)	451	5798.8	2333.0	1720.0	18358.2
Unit Median (rmb per sqm)	451	5849.1	2315.3	2075.0	18119.8

Table 4. Statistics of Three Measurements of Unit Price Per Street Block, Chengdu 2005-2010

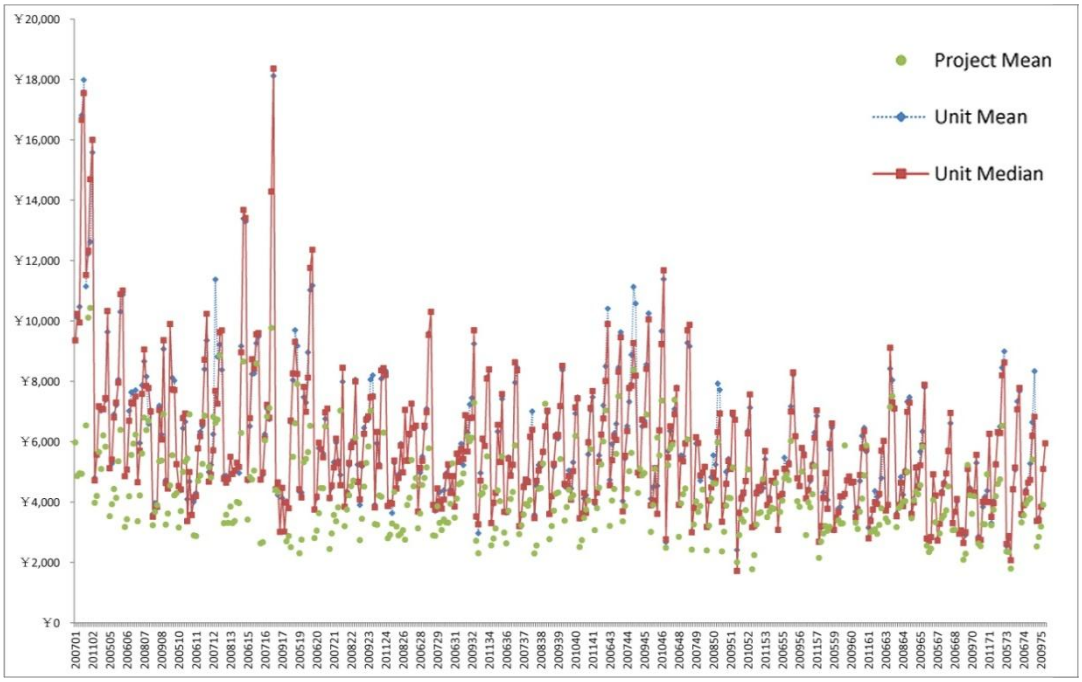


Figure 17. Three Measurements of Unit Price Per Street Block, Chengdu 2005-2010

Second, a dummy variable, "whether the distance between the centroid of street block to the closest station of subway line1 is less than 1,000 meters", is introduced. Line1 is the only subway currently under operation. In refer to Section 4.1, the LOG(D_SUBWAY) is significant in transaction-sample based model but insignificant at street block level. Probable cause mentioned by local expert is that the city has only one subway line (17 stations). The line runs

straight N/S through 12 street blocks, connecting important land marks such as two train stations on each end, the CBD and the secondary city center on the south. Within its 1,000m radius, most areas are for commercial and public use, with limited housing. The small numbers of samples at street block level that can be affected by subway is probably the reason that results in insignificant result in the model. The dummy variable is used to replace the distance variable in the hope that the result can be significant. Though eventually it still doesn't change the result, proximity to subway (both line1 and line2) is considered important factor in local market.

The third improvement is the introduction of subgroups classified by size of unit (price of Unit Mean and Unit Median both tested). During the field meeting, local experts highlight the fact that the size of unit largely determines the target clientele in the market. Also unit size, serving the corresponding target, can also determine its physical characteristics and unit price. For example, VANKE, as the largest housing developer in China by gross sale, generalizes housing product into three main types and eight refined subgroups, all by unit size. Three main types are (1) Economic Unit for first-time home buyer (2) Comfortable Unit for home-upgrade buyer and second-home buyer (3) Luxury Unit for the entire families to live together and for investment. Every type has its own distinctive focuses in different order. For example, first-time home buyers value the following housing unit features in downward magnitude of importance: total price, location, plan layout efficiency, unit price, service and amenity, quality of landscape and physical condition of the building. Other types may value same elements in different order and include new criteria. Locational features and demographic composition are important determinants when developers make decision what type(s) of unit product(s) to be built. Chengdu, as a classic monocentric city with undersupplied public amenities and infrastructure,

has wide range of unit composition in various street blocks. Some street blocks, with balanced demographic composition and locational features, provide more diversified unit products, whereas some street blocks could be very monotonous. Based upon the above, local experts suggest that further refined hedonic models classified by unit size are necessary to be tested in order to reveal differed significance of explanatory variables corresponding to various housing product. Three subgroups are created based on unit sizes (1) <= 90sqm (total transaction samples 286,408) (2) 90-144sqm (inclusive) (total transaction samples 189,703) (3) >144sqm (total transaction samples 36,981). Total transaction samples are, again, 513,092.

The fourth improvement focuses on one explanatory variable, Per Capita Fixed Investment. The data acquired from yearbook of local municipal website at www.cdstats.chengdu.gov.cn only provides flow information, not the stock of fixed investment per district per year. The model prior to the field trip also applied the flow of per capita fixed investment. The improved model introduces cumulative flow as a proxy of the stock information, using flow information in 2005 as base. The explanatory variable used in the model is one-year lag of per capita cumulative fixed investment. As stated in Section 4.1, Fixed Investment is an indicator of infrastructure investment by local government. Here infrastructure is a broad concept including both general infrastructure such as subway, road, bridge, and also real estate. Lastly, another new dummy variable, Dummy_Tianfu Zone, is introduced. Tianfu New Economic Zone is a special economic district and emerging 2nd city center in south. Southern portion of subway line1 is in the heart of the zone. New municipalities and new service industry are located in the zone. According to Chengdu Population Census and Economy Census, only street block No.72 is in Tianfu Zone. (Fig. 13)

With these five improvements, more exercises of Level Model are taken with the results reported in the following three tables. Table 5 exhibits four results of Level Model, all at street block level without dividing into subgroups. Column (1) and Column (2) use the same project mean unit price on the left hand side. The explanatory variables on the right hand side are different. Column (2), (3) and (4) use the same explanatory variables on the right hand side. The unit price on the left hand side is measured differently using Project Mean, Unit Mean and Unit Median three approaches. Column (1) is the same result from Table 3. The results are consistent no matter which unit price measurement is used. Among three groups of explanatory variables, physical attributes are in general less significant than Locational features, Economic and Demographic characteristics. It is consistent with the argument in Section4.1 that transaction samples are condominiums that are quite similar in building structure, internal space, decoration, and even age because they are all new housing units. In the category of locational features, Distance to CBD remains very significant, same are Distance to Core Primary School and Distance to Shopping Mall. The results again highlight the monocentric city characteristics with limited social goods and public amenities. Subway dummy remains insignificant which is still due to insufficient samples at street-block level that can be affected by subway line1. The sign of coefficient of spatial explanatory variables cross four columns are consistent; the absolute values are pretty close. Economic and demographic characteristics exhibit high significance cross all four columns. An interesting observation is the positive sign of per capita fixed investment (flow) and negative sign of per capital cumulative fixed investment with 1 year lag (stock). Probable argument is: the positive coefficient of flow variable indicates that increased per capita investment in infrastructure will improve physical condition of the street block, which in turn stimulates unit price appreciation. The negative coefficient of stock variable indicates

that increased per capital cumulative investment in fixed property especially housings, on the other hand produces more supply, which in turn lowers unit price. The new dummy variable, Tianfu_Zone is constantly significant cross column (2), (3) and (4). It is safe to state that price premium is obvious and high in street block No.72, where the 2nd city center is emerging.

$Log(P_{project\ mean})$ = Definition1, Section 3.1, $Log(P_{unit\ mean})$ = Definition2, Section 3.1
$Log(P_{unit\ median})$ = Definition3, Section 3.1

	(1) $Log(P^{before\ trip}_{project\ mean})$	(2) $Log(P^{after\ trip}_{project\ mean})$	(3) $Log(P_{unit\ mean})$	(4) $Log(P_{unit\ median})$
P_FLOOR[#]	0.00470	0.00465	0.00848**	0.00780**
(unit floor)	(1.41)	(1.37)	(2.39)	(2.43)
Log(P_HSIZE)[#]	0.0730*	0.0358	0.0594	-0.0255
(unit size, in sqm)	(1.69)	(0.78)	(1.16)	(-0.54)
Log(P_PSIZE)[#]	0.0280	0.0338	0.0312	0.0189
(project size, in 000 units)	(1.45)	(1.60)	(1.38)	(0.94)
D_CBD	-0.0212***	-0.0245***	-0.0384***	-0.0366***
(in km)	(-4.04)	(-4.94)	(-7.03)	(-6.83)
Dummy_SUBWAY		-0.0122	-0.0114	0.00531
(whether in 1km radius)		(-0.49)	(-0.41)	(0.19)
LOG(D_SUBWAY)	-0.00730			
(in km)	(-0.58)			
LOG(D_PRIMARY)	-0.0266**	-0.0386***	-0.0314**	-0.0337**
(in km)	(-2.16)	(-3.00)	(-2.19)	(-2.37)
LOG(D_MALL)	-0.0365**	-0.0448***	-0.0497***	-0.0536***
(in km)	(-2.57)	(-2.98)	(-2.97)	(-3.26)
LOG(D_RIVER)	-0.0273**	-0.0327**	-0.00509	-0.00364
(in km)	(-2.29)	(-2.53)	(-0.35)	(-0.25)
LOG(D_PARK)	-0.00400	0.00392	-0.0224	-0.0187
(in km)	(-0.24)	(0.22)	(-1.13)	(-0.95)
E_3rdRATIO	0.122			
(GDP of tertiary industry over total GDP)	(0.45)			
LOG(E_POPDEN)	0.247***	0.375***	0.302***	0.293***
(in pop/kilo square meter)	(2.61)	(4.12)	(3.01)	(2.95)
LOG(E_PURCHASE)	0.722***	1.011***	1.112***	0.910***
(in RMB per capita)	(2.83)	(3.09)	(3.15)	(2.60)
LOG(E_FIXEDINVEST)	0.137***	0.351**	0.349**	0.275*
(in 100million RMB per capita, flow)	(3.08)	(2.42)	(2.20)	(1.75)
LOG(E_CUMFIXED)_lag1		-0.235*	-0.306**	-0.243
(in￥100million per capita, stock)		(-1.68)	(-2.00)	(-1.60)
Year Fixed Effect	YES	YES	YES	YES
Dummy_Tianfu Zone[Δ]		0.206**	0.235**	0.260***
(whether the street block is in Tianfu Zone*)		(2.36)	(2.39)	(2.68)
Constant	4.271***	1.677	1.085	2.541
	(2.72)	(0.86)	(0.51)	(1.20)
No. of Obs.	372	324	339	339
R^2	0.693	0.671	0.631	0.635

Table 5. Level Model, Three Measurements of Unit Price per Street Block (2005-2010)

t statistics in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
#: explanatory variable measured by either Mean or Median, according to unit price is measured on the left hand side; for price measured by project mean in definition 1, explanatory variable measured also by Mean.
Δ: Only Street Block No. 72 is in TianFu Zone, a special economic district and 2nd center in southern city

Table 6 (Mean price) and Table 7 (Median price) exhibit Level Model results cross different subgroups by unit size. Column (1) in both tables is all street-block level without subgroup classification. Some findings are observed. First, the sign of coefficient of all explanatory variables is consistent in two tables using Unit Mean and Unit Median respectively; and the absolute values of coefficients in the two tables are very close. It indicates that the underlying dataset is normal distribution (Table 4) and either Unit Mean or Unit Median is good base for discussion.

It is interesting noticing that subgroup based on unit size responds to explanatory variables differently. In the category of physical attribute, two negative gradients with significance are noticed. The negative coefficient of Unit Size of smaller than 90sqm (inclusive) subgroup indicates that the smaller the unit size is, the higher the unit price is. It is consistent with the fact in the market that unit for speculation and investment can be very small and at very good location. Such small unit is normally equipped with high-quality service and amenity. Crosschecking unit product matrix from VANKE, the refined eight subgroups show that not all small units are for first-time buyer. In fact, unit between 75sqm and 90sqm is more preferred by first-time home buyer. Unit smaller than 60sqm and located in the core of city is much preferred by investors. Such unit can be very expensive in unit price, but still investable because of relatively low total price. On the contrary, unit size coefficient is positive for middle and large size unit (90-144sqm, and above 144sqm). And subgroup of large size unit (>144sqm) has high positive coefficient of Unit Size with $p<0.01$ in Unit Mean report. It again reinforces the finding

in the market that large unit is undersupplied. Also households who buy large unit are normally wealthy families. When they compete for undersupplied large size unit, the premium can go very high. Coefficient of Project Size is negatively significant for large size subgroup (>144sqm). It is consistent with the fact that households who buy large unit prefer project with less density and low FAR.

Looking at locational features cross three unit size subgroups, Distance to CBD becomes less significant as unit size enlarges. On the other hand, Distance to Mall and Distance to Park become more significant with higher absolute coefficient when unit size grows. It indicates that household living in large unit concerns less about commute distance because they drive. However, other public goods, especially the ones pertinent to living quality become more important concerns to these wealthy families. Distance to Core Primary School is highly regarded by household living in small unit (<=90sqm). It is probably because smaller units accommodate more young couples who are raising children at age for primary school. Among four economic and demographic characteristics, Per Capita Purchase Power is positively significant with $p<0.01$ cross all three subgroups. The absolute coefficient is the highest in subgroup of the largest unit (>144sqm). Per Capita Purchase Power, a proxy of rich or poor street block, clearly shows that the richer households in a street block are, the more expensive the unit price is. And the steepest gradient occurs in the wealthiest households in subgroup of the largest unit size. Tianfu_Zone dummy is significant in small and middle size unit subgroups, but insignificant in large size subgroup. The arguments can be a few. Although Tianfu_Zone is forming 2nd city center, the type of service job, the infrastructure development and the social amenities are still less attractive to wealthy households who prefer living in large unit.

Comparing to Tianfu_Zone in south, the location at west within 2nd ring road is closer to the core of the city, with well-developed diversified social amenities. Another reason is probably because of insufficient transactions of large unit in street block No. 72. The discussion about different capitalization effects on subgroups of unit size by various population compositions can be more revealing if more detailed demographic information, such as population by age, household income and education level are available.

$Log(P_{mean})$ = Definition2, Section 3.1

	(1) $Log(P_{mean})$	(2) $Log(P_{mean})$_<=90	(3) $Log(P_{mean})$_90-144	(4) $Log(P_{mean})$_>144
$P\_FLOOR_{(mean)}$	0.00848**	0.00285**	0.00571***	0.00423***
(mean floor of units)	(2.39)	(2.05)	(4.52)	(2.66)
$Log(P\_HSIZE)_{(mean)}$	0.0594	-0.194**	0.262*	0.422***
(mean size of units, in sqm)	(1.16)	(-2.48)	(1.94)	(2.68)
$Log(P\_PSIZE)_{(median)}$	0.0312	0.0394*	-0.00240	-0.0786***
(mean size of projects, in 000 units)	(1.38)	(1.84)	(-0.11)	(-2.66)
D_CBD	-0.0384***	-0.0115***	-0.0159***	-0.00704
(in km)	(-7.03)	(-4.61)	(-7.19)	(-1.62)
Dummy_SUBWAY	-0.0114	0.00751	-0.00742	-0.0239
(whether in 1km radius)	(-0.41)	(0.64)	(-0.65)	(-1.14)
LOG(D_PRIMARY)	-0.0314**	-0.0185***	-0.00945	0.0120
(in km)	(-2.19)	(-3.05)	(-1.59)	(1.15)
LOG(D_MALL)	-0.0497***	-0.0248***	-0.00831	-0.0470***
(in km)	(-2.97)	(-3.55)	(-1.22)	(-3.61)
LOG(D_RIVER)	-0.00509	-0.00808	0.00423	0.00791
(in km)	(-0.35)	(-1.29)	(0.74)	(0.69)
LOG(D_PARK)	-0.0224	-0.00704	-0.0161**	-0.0571***
(in km)	(-1.13)	(-0.85)	(-1.99)	(-3.77)
LOG(E_POPDEN)	0.302***	0.0956**	0.0625	0.256***
(in pop/kilo square meter)	(3.01)	(2.27)	(1.53)	(3.35)
LOG(E_PURCHASE)	1.112***	0.502***	0.430***	1.683***
(in￥per capita)	(3.15)	(3.38)	(2.93)	(4.87)
LOG(E_FIXEDINVEST)	0.349**	0.162**	0.0789	0.503***
(in￥100million per capita, flow)	(2.20)	(2.41)	(1.20)	(3.58)
LOG(E_CUMFIXED)_lag1	-0.306**	-0.139**	-0.0787	-0.378***
(in￥100million per capita, stock)	(-2.00)	(-2.13)	(-1.24)	(-2.85)
Year Fixed Effect	YES	YES	YES	YES
Dummy_Tianfu Zone$^{\Delta}$	0.235**	0.124***	0.0820**	0.0413
(whether the street block is in Tianfu Zone*)	(2.39)	(3.04)	(2.10)	(0.69)
Constant	1.085	1.463	0.853	-5.147***
	(0.51)	(1.62)	(0.94)	(-2.68)
Observations	339	327	318	203
R^2	0.631	0.632	0.629	0.516

t statistics in parenthesis, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Δ: Only Street Block No. 72 is in TianFu Zone, a special economic district and 2nd center in southern city

Table 6. Level Model, Unit Price per Street Block = Unit Mean, Chengdu (2005-2010)

$Log(P_{median})$ = Definition3, Section 3.1

	(1) $Log(P_{median})$	(2) $Log(P_{med})\_<=90$	(3) $Log(P_{med})\_90\text{-}144$	(4) $Log(P_{med})\_>144$
$P\_FLOOR_{(median)}$	0.00780**	0.00242*	0.00528***	0.00320**
(median floor of units)	(2.43)	(1.90)	(4.17)	(2.05)
$Log(P\_HSIZE)_{(median)}$	-0.0255	-0.160**	0.262**	0.342**
(median size of units, in sqm)	(-0.54)	(-2.37)	(2.34)	(2.13)
$Log(P\_PSIZE)_{(median)}$	0.0189	0.0212	-0.0262	-0.0869***
(median size of projects, in 000 units)	(0.94)	(1.06)	(-1.26)	(-3.10)
D_CBD	-0.0366***	-0.0125***	-0.0162***	-0.00789*
(in km)	(-6.83)	(-4.83)	(-6.75)	(-1.75)
Dummy_SUBWAY	0.00531	0.0114	-0.00360	-0.0122
(whether in 1km radius)	(0.19)	(0.91)	(-0.29)	(-0.56)
LOG(D_PRIMARY)	-0.0337**	-0.0171***	-0.0121*	0.00831
(in km)	(-2.37)	(-2.64)	(-1.88)	(0.76)
LOG(D_MALL)	-0.0536***	-0.0240***	-0.00968	-0.0476***
(in km)	(-3.26)	(-3.26)	(-1.32)	(-3.55)
LOG(D_RIVER)	-0.00364	-0.00843	0.00276	0.00907
(in km)	(-0.25)	(-1.27)	(0.44)	(0.77)
LOG(D_PARK)	-0.0187	-0.00671	-0.0131	-0.0529***
(in km)	(-0.95)	(-0.76)	(-1.50)	(-3.37)
LOG(E_POPDEN)	0.293***	0.105**	0.0683	0.248***
(in pop/kilo square meter)	(2.95)	(2.34)	(1.54)	(3.13)
LOG(E_PURCHASE)	0.910***	0.473***	0.431***	1.651***
(in ¥ per capita)	(2.60)	(3.00)	(2.70)	(4.69)
LOG(E_FIXEDINVEST)	0.275*	0.161**	0.0742	0.525***
(in ¥ 100million per capita, flow)	(1.75)	(2.25)	(1.04)	(3.63)
LOG(E_CUMFIXED)_lag1	-0.243	-0.139**	-0.0839	-0.407***
(in ¥ 100million per capita, stock)	(-1.60)	(-2.00)	(-1.21)	(-2.98)
Year Fixed Effect	YES	YES	YES	YES
Dummy_Tianfu Zone$^{\Delta}$	0.260***	0.138***	0.0927**	0.0366
(whether the street block is in Tianfu Zone*)	(2.68)	(3.19)	(2.19)	(0.60)
Constant	2.541	1.286	0.809	-4.807**
	(1.20)	(1.35)	(0.83)	(-2.43)
Observations	339	327	318	203
R^2	0.635	0.607	0.586	0.501

t statistics in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Δ: Only Street Block No. 72 is in TianFu Zone, a special economic district and 2nd center in southern city

Table 7. Level Model, Unit Price per Street Block = Unit Median, Chengdu (2005-2010)

Using $P_{project\ mean}^{after\ trip}$ in Table 5, GIS diagrams are updated. Year2005 is omitted since it is the base year of the Cumulative Fixed Investment and no Year2004 information is available.

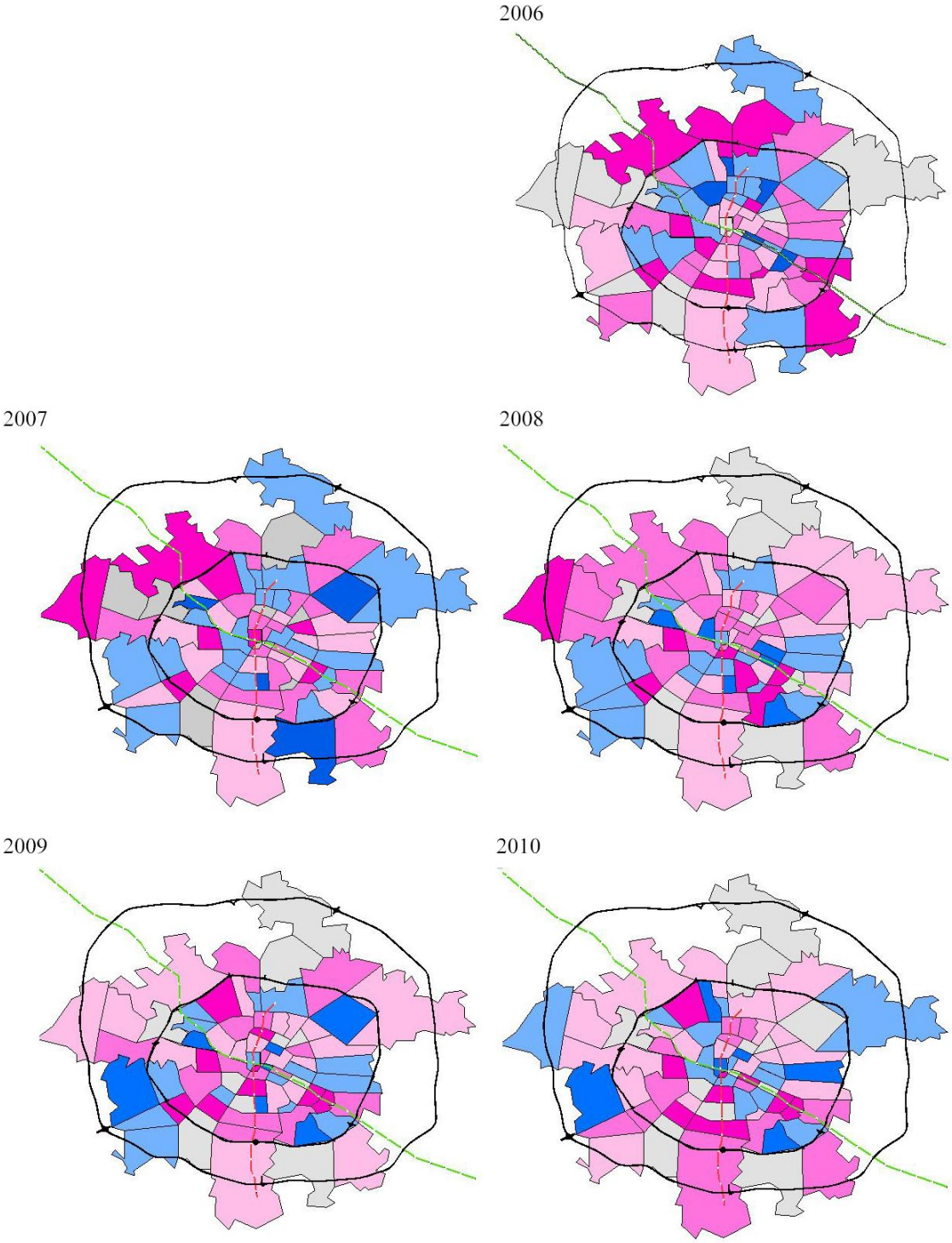
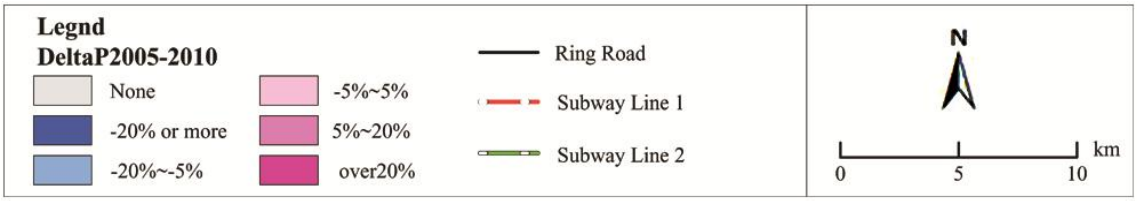


Figure 18. Updated (Exp(Ɛresidual)-100%), Actual Price vs. Model Predicted Price



4.4 Change Model Test and Result

Change Model studies: what are the determinants that affect housing price movement in time? In the past decade, housing price in China has not shown cyclical syndrome. During 2005-2010, housing price grows constantly. Hence the question becomes: what are the determinants that affect housing price appreciation in time? During the field meeting, a preliminary housing price change graph is discussed. (Fig.19) The color is indicator of percentage change of actual unit price between 2005 and 2010. The unit price is calculated using Project Mean in Definition1, Section 3.1. More saturated magenta means larger price appreciation in 5-year span. The maps also display the utmost express beltway, the 3rd ring road within the express beltway. Subway line1 in red, which started operation by end of 2010, and subway line2 in green, which is for operation by end of 2012, are also shown in the maps.

The discussion focuses on street block No.75 on the far east between 3rd ring road and the express beltway, with the most saturated magenta. At the beginning local experts are surprised noticing that this street block exhibits the largest price appreciation. It is among all 75 street blocks the weakest one in terms of locational features and economic strength. The street block is very unattractive to household. Further discussion reveals that although both the initial price in 2005 and the ending price in 2010 are low in the street block, the percentage growth (price

change over initial price, minus 100%) is high. In some other street blocks, although the initial and ending price are much higher than street block 75, the percentage growth is small. In fact, Professor Zheng later points out that street block No.75 is a typical convergence effect. Although the street block does not undertake much of locational and economic improvement over time, the growth of the city, as an exogenous stimulus, sheds light on it and stimulates its growth. This finding inspires the following Chang Model exercises to take account for the initial and inherent characteristics of a street block that can affect housing price movement in time.

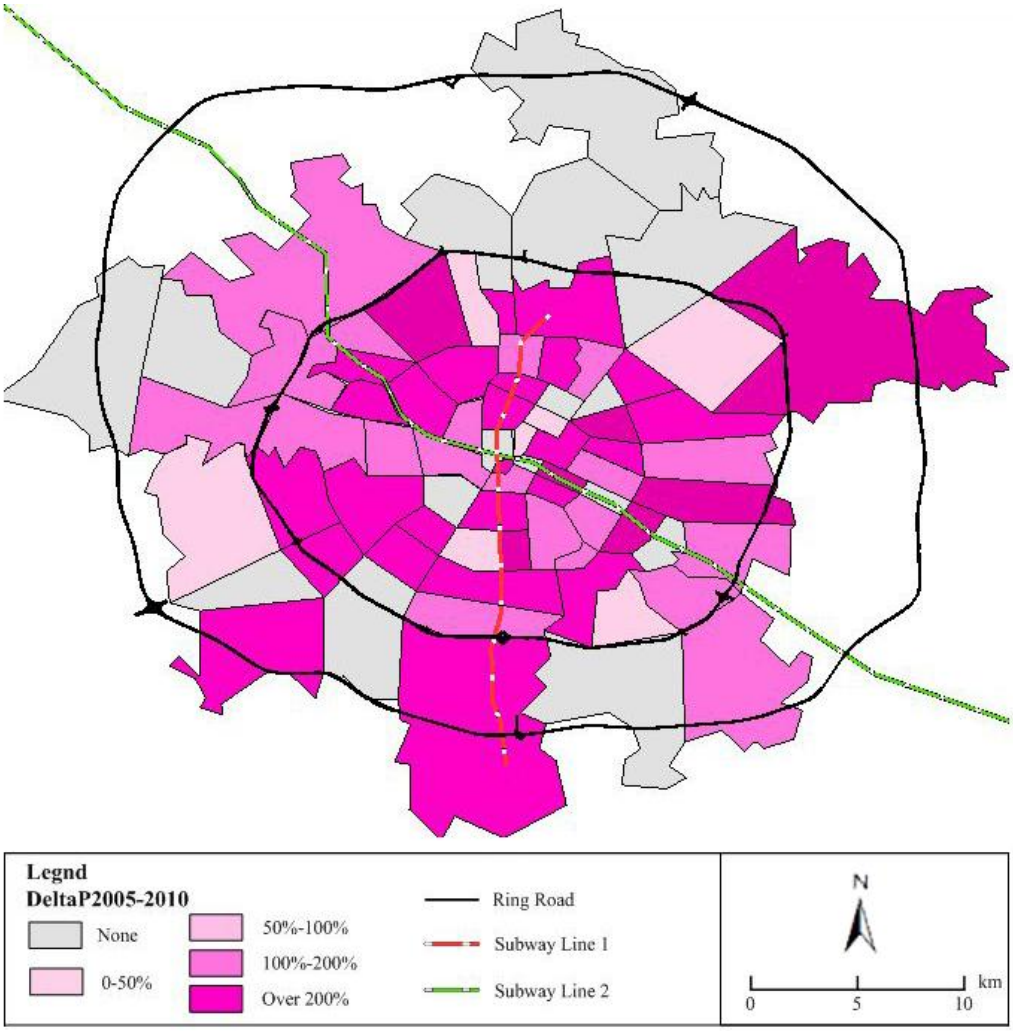


Figure 19. Housing Price Change = (Price2010-Price2005)/(Price2005)

Exercise of Change Model starts with Eq.3. The approach is consistent with Level Model in Eq.2. Because of small amount of observations at 5-year span, Change Model exercise introduces both 1-year and 5-year span. (1) ΔX_n^P represents change of a series of Physical attributes of units in the corresponding street block in years; (2) ΔX_n^D represents change of a series of Distance to locational features in the corresponding street block in years; (3) ΔX_n^E represents change of a series of Economic and demographic characteristics in the corresponding street block in years. Because variables of distance to locational feature remain unchanged in time, ΔX_n^D cancel out. ΔX_n^P, the change of physical attributes of unit in time, should not be significant determinants of housing price movement in time. Therefore, Change Model in Eq.3 is essentially looking for how the change of economic and demographic characteristics in time can move price. Unfortunately, the regression result is not good at all. The variables are not significant at all and are in reversed sign. The reasons include, aside from data insufficiency, low economic and demographic data quality (see Section 3.4), and short time frame. Professor Zheng later points out that instead of Delta factors, Level factors probably play more important role in moving unit price in time. Inspired by the discussion during the field trip, the initial characters and the inherent characters of a street block replace original Delta variables in the Change Model.

Exercise of Change Model is then modified to Eq.4. Here (1) $X_n^{\text{Initial Price}}$ becomes initial price at the beginning year; (2) X_n^D are same explanatory variables representing distance to locational features in the Level Model. They are considered as inherent characters of the street block; (3) $X_n^{\text{E\_fixed invest}}$ is the only Delta economic factor and only used in short-term exercise. In 5-year term, the variable substantially reduces observations, hence omitted. The variable is the same

flow of per capital fixed investment in the Level Model; (4) Year dummy and TianFu_Zone dummy, the two same variables in the Level Model are kept. Similar to Level Model, delta unit price on the left hand side of the equation tests both ΔP_{mean} and ΔP_{median}. Four reports are presented: Table 8_ $\Delta P_{mean\ (1yr)}$, Table 9_ $\Delta P_{mean\ (5yr)}$, Table 10_ $\Delta P_{median\ (1yr)}$, and Table 11_ $\Delta P_{median\ (5yr)}$.

Eq.3

$$\text{Log}\ (\Delta P_n^{PDE}) = \textit{Cons.} + \beta_P * \Delta X_n^{P} + \beta_D * \Delta X_n^{D} + \beta_E * \Delta X_n^{E} + \textit{Year Dummy} + \varepsilon_{\text{residual}} \quad (n=1, 2 \ldots 75)$$

Eq.4

$$\text{Log}\ (\Delta P_n^{PDE}) = \textit{Cons.} + \beta_P * X_n^{P\_\text{initial Price}} + \beta_D * X_n^{D} + \beta_E * X_n^{E\_\text{fixedinvest}} + \textit{Dummy\_Year} + \textit{Dummy\_Tianfu\_Zone} + \varepsilon_{\text{residual}} \quad (n=1, 2 \ldots 75)$$

Similar to the results in Level Model, the signs of coefficient of all explanatory variables are consistent in two tables using Unit Mean and Unit Median respectively. The absolute values of coefficients in the two tables are very close. It indicates that the underlying dataset is normal distribution. Either Unit Mean or Unit Median is good base for discussion. The constant high significance of Initial Price (in all four exercises, most results are $p<0.01$) reinforces the point discussed in the local office. The Initial Price ($P_{\_lag1}$ in 1-year and $P_{\_lag5}$ in 5-year) plays very significant role determining price appreciation in the following years. The negative sign indicates that the higher the initial price, the less growth the price will be in the ending year, vice versa. Another interesting observation from P_{med} exercise is that in 1-year, the absolute value of Log(P_{med}_lag1) coefficient of the largest subgroup (>144sqm) is the smallest among all three subgroups (coefficient=-.290, $p<0.01$). Whereas in 5-year, Log(P_{med}_lag5) is the largest

(coefficient=-.901, $p<0.10$). The absolute value of Log(P_{med}_lag1) coefficient of the smallest subgroup (<=90sqm) is the median (coefficient=-.450, $p<0.01$), not far from the largest absolute value from the middle size unit. Whereas in 5-year, Log(P_{med}_lag5) is again the median (coefficient=-.897, $p<0.01$), also not far from the largest absolute value from the largest size unit. From holding-period-return perspective, smallest unit with low initial unit price is good for both short and long term investment. Largest unit with low initial unit price, on the other hand, may be good for long-term investment. Middle size unit with low initial price is good for risk-averse investment.

Between 1-year and 5-year Change Models, the results of inherent locational features are more significant in the short term. Among all six locational features (Distance to CBD, Distance to Core Primary School, Distance to Shopping Mall, Distance to Park, Distance to River, and Subway Dummy), Distance to CBD is significant with $p<0.01$ in P_{median} 1-year Change Model. Distance to Core Primary School and Distance to Shopping Mall are also significant with good p results. They clearly reinforce the analysis in Section2.2 that Chengdu is a monocentric city, in which social amenities and public goods are limited and concentrated in the core of city. Inherent locational features, including Distance to CBD, Distance to Core Primary school, and Distance to Shopping Mall are not only important determinants that decide housing price cross 75 street blocks at one time, they are also significant determinants moving unit price appreciation in time. Households not only are willing to pay unit price premium for location with good public amenities and social goods, they also anticipate that unit price appreciation will be larger in these locations. Given the fact that the city is growing rapidly with large number of migrants moving in, it is expected that public amenities will be continuously scarce and highly determinant to

affect housing price. The significance of Tianfu_zone dummy in 1-year P_{median} model indicates that the 2nd city center has been accepted by the market and its capitalization effect is manifesting, consistent with GIS diagram in Fig.16.

$Dlt\_Log(P_{mean}) = Log(Price_{(YR\_X\_mean)}) - Log(Price_{(YR\_X-1\_mean)})$, Definition2,Section 3.1

	(1) $Dlt\_Log(P_{mean})$ _1yr lag	(2) $Dlt\_Log(P_{mean})$ _<=90_1yr lag	(3) $Dlt\_Log(P_{mean})$ _90-144_1yr lag	(4) $Dlt_Log(P_{mean})$_ > 144_1yr lag
$Log(P_{mean})$_lag1 (price in last year)	-0.336*** (-6.26)	-0.400*** (-7.02)	-0.432*** (-7.22)	-0.225*** (-3.09)
D_CBD (in km)	-0.0121** (-2.41)	-0.00520** (-2.36)	-0.00697*** (-3.01)	-0.00312 (-0.80)
Dummy_SUBWAY (whether in 1km radius)	0.00998 (0.43)	0.0106 (1.02)	-0.00249 (-0.24)	-0.00236 (-0.13)
LOG(D_PRIMARY) (in km)	-0.0224* (-1.90)	-0.0140*** (-2.63)	-0.00704 (-1.35)	-0.0138 (-1.57)
LOG(D_MALL) (in km)	-0.0337** (-2.40)	-0.0182*** (-2.94)	-0.00577 (-0.94)	-0.0161 (-1.38)
LOG(D_RIVER) (in km)	-0.0107 (-0.94)	-0.00681 (-1.30)	-0.000493 (-0.10)	-0.00779 (-0.76)
LOG(D_PARK) (in km)	-0.0236 (-1.42)	-0.00679 (-0.93)	-0.0136* (-1.86)	-0.0265* (-1.92)
LOG(E_FIXEDINVEST) (in￥100million per capita, flow)	-0.0141 (-0.41)	-0.00750 (-0.48)	-0.00588 (-0.40)	-0.0663** (-2.24)
Year Fixed Effect	YES	YES	YES	YES
Dummy_Tianfu Zone$^{\Delta}$ (whether the street block is in Tianfu Zone*)	0.144* (1.80)	0.0650* (1.85)	0.0560* (1.67)	0.0858* (1.79)
Constant	3.504*** (5.12)	1.781*** (5.66)	1.727*** (5.65)	0.454 (0.91)
Observations	312	295	283	162
R^2	0.246	0.291	0.272	0.220

t statistics in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Δ: Only Street Block No. 72 is in TianFu Zone, a special economic district and 2nd center in southern city

Table 8. Change Model_1yr lag, Unit Price per Street Block = Unit Mean, Chengdu (2005-2010)

$Dlt\_Log(P_{mean}) = Log(Price_{(2010\_mean)}) - Log(Price_{(2005\_mean)})$, Definition2,Section 3.1

	(1) $Dlt_Log(P_{mean})$_ 5yr lag	(2) $Dlt_Log(P_{mean})$_ <=90_5yr lag	(3) $Dlt_Log(P_{mean})$_ 90-144_5yr lag	(4) $Dlt_Log(P_{mean})$_ > 144_5yr lag
$Log(P_{mean})\_lag5$	-0.576***	-0.844***	-0.498**	-0.641
(price in 2005)	(-2.88)	(-3.76)	(-2.37)	(-1.39)
D_CBD	-0.0102	-0.0132	-0.000961	-0.00480
(in km)	(-0.61)	(-1.64)	(-0.13)	(-0.23)
Dummy_SUBWAY	0.0251	0.00518	-0.00880	-0.102
(whether in 1km radius)	(0.38)	(0.16)	(-0.29)	(-1.59)
LOG(D_PRIMARY)	-0.107***	-0.0576***	-0.0340**	-0.0538
(in km)	(-3.24)	(-3.39)	(-2.31)	(-1.59)
LOG(D_MALL)	-0.0590	-0.0295	-0.00824	-0.108**
(in km)	(-1.43)	(-1.45)	(-0.42)	(-2.31)
LOG(D_RIVER)	-0.0665**	-0.0200	-0.0293**	-0.0259
(in km)	(-2.09)	(-1.17)	(-2.05)	(-0.65)
LOG(D_PARK)	0.0247	0.0169	-0.00618	-0.0453
(in km)	(0.52)	(0.73)	(-0.30)	(-0.92)
Year Fixed Effect	YES	YES	YES	YES
Dummy_Tianfu Zone$^{\Delta}$	0.350*	0.158	0.111	0.327**
(whether the street block is in Tianfu Zone*)	(1.71)	(1.61)	(1.29)	(2.17)
Constant	6.820***	3.982***	2.578***	4.195**
	(3.71)	(4.50)	(3.07)	(2.30)
Observations	94	81	82	39
R^2	0.224	0.277	0.227	0.365

t statistics in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Δ: Only Street Block No. 72 is in TianFu Zone, a special economic district and 2nd center in southern city

Table 9. Change Model_5yr lag, Unit Price per Street Block = Unit Mean, Chengdu (2005-2010)

$Dlt\_Log(P_{med}) = Log(Price_{(YR\_X\_median)}) - Log(Price_{(YR\_X-1\_median)})$, Definition3,Section 3.1

	(1) Dlt_Log(P_{med}) _1yr lag	(2) Dlt_Log(P_{med}) _<=90_1yr lag	(3) Dlt_Log(P_{med})_ 90-144_1yr lag	(4) Dlt_Log(P_{med}) _> 144_1yr lag
Log(P_{median})_lag1 (price in last year)	-0.447*** (-7.99)	-0.450*** (-7.59)	-0.510*** (-7.58)	-0.290*** (-3.76)
D_CBD (in km)	-0.0186*** (-3.56)	-0.00739*** (-3.11)	-0.00846*** (-3.18)	-0.00453 (-1.08)
Dummy_SUBWAY (whether in 1km radius)	0.0134 (0.55)	0.0118 (1.04)	-0.00165 (-0.14)	-0.00638 (-0.32)
LOG(D_PRIMARY) (in km)	-0.0296** (-2.38)	-0.0159*** (-2.77)	-0.0104* (-1.71)	-0.0130 (-1.37)
LOG(D_MALL) (in km)	-0.0381** (-2.58)	-0.0183*** (-2.72)	-0.00765 (-1.08)	-0.0179 (-1.41)
LOG(D_RIVER) (in km)	-0.00686 (-0.57)	-0.00632 (-1.11)	-0.00126 (-0.22)	-0.00681 (-0.61)
LOG(D_PARK) (in km)	-0.0149 (-0.86)	-0.00536 (-0.67)	-0.0122 (-1.46)	-0.0287* (-1.94)
LOG(E_FIXEDINVEST) (in￥100million per capita, flow)	-0.0105 (-0.29)	-0.00989 (-0.58)	-0.0111 (-0.65)	-0.0639** (-1.99)
Year Fixed Effect	YES	YES	YES	YES
Dummy_Tianfu Zone$^{\Delta}$ (whether the street block is in Tianfu Zone*)	0.159* (1.90)	0.0783** (2.05)	0.0661* (1.70)	0.0853 (1.64)
Constant	4.492*** (6.34)	1.942*** (5.83)	1.980*** (5.80)	0.747 (1.41)
Observations	312	295	283	162
R^2	0.290	0.310	0.254	0.229

t statistics in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Δ: Only Street Block No. 72 is in TianFu Zone, a special economic district and 2nd center in southern city

Table 10. Change Model_1yr lag, Unit Price per Street Block = Unit Median, Chengdu (2005-2010)

$Dlt\_Log(P_{med}) = Log(Price_{(2010\_median)}) - Log(Price_{(2005\_median)})$, Definition3,Section 3.1

	(1) $Dlt_Log(P_{med})$_ 5yr lag	(2) $Dlt_Log(P_{med})$_ <=90_5yr lag	(3) $Dlt_Log(P_{med})$_ 90-144_5yr lag	(4) $Dlt_Log(P_{med})$_ > 144_5yr lag
$Log(P_{median})\_lag5$	-0.662***	-0.897***	-0.544**	-0.901*
(price in 2005)	(-3.44)	(-4.08)	(-2.38)	(-1.85)
D_CBD	-0.0217	-0.0182**	-0.00219	-0.00850
(in km)	(-1.29)	(-2.12)	(-0.27)	(-0.40)
Dummy_SUBWAY	0.0195	0.00698	-0.0126	-0.113
(whether in 1km radius)	(0.29)	(0.20)	(-0.38)	(-1.68)
LOG(D_PRIMARY)	-0.108***	-0.0629***	-0.0379**	-0.0477
(in km)	(-3.19)	(-3.42)	(-2.32)	(-1.36)
LOG(D_MALL)	-0.0503	-0.0309	-0.0140	-0.115**
(in km)	(-1.19)	(-1.39)	(-0.66)	(-2.36)
LOG(D_RIVER)	-0.0694**	-0.0145	-0.0425***	-0.0393
(in km)	(-2.12)	(-0.79)	(-2.72)	(-0.95)
LOG(D_PARK)	0.0376	0.0162	-0.00653	-0.0516
(in km)	(0.78)	(0.65)	(-0.29)	(-0.98)
Year Fixed Effect	YES	YES	YES	YES
Dummy_Tianfu Zone$^{\Delta}$	0.353*	0.172	0.137	0.318*
(whether the street block is in Tianfu Zone*)	(1.68)	(1.62)	(1.45)	(2.00)
Constant	7.472***	4.220***	2.898***	5.298***
	(4.18)	(4.85)	(3.19)	(2.84)
Observations	94	81	82	39
R^2	0.241	0.289	0.250	0.404

t statistics in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Δ: Only Street Block No. 72 is in TianFu Zone, a special economic district and 2nd center in southern city

Table 11. Change Model_5yr lag, Unit Price per Street Block = Unit Median, Chengdu (2005-2010)

Chapter 5. Conclusion

In the thesis, two regression models, Level Model and Change Model are exercised to explore two questions: What are determinants of housing unit price difference cross section and what are determinants of housing unit price movement in time? The findings are consistent cross the models and with the market. In addition to Physical attributes, and Locational features, the two categories already studied by scholars in previous researches, the thesis finds that Economic and Demographic characteristics, the representations of economic growth, industrial restructuring and demographic transformation are also significant determinants being capitalized into housing price at various levels. In a rapid growing city like Chengdu, the thesis also finds that instead of the change of the determinants, inherent characteristics of the location features and the initial price actually play more important role moving unit price in both short-term (1-year) and relatively long-term (5-year).

Detailed findings from Level Model exercise highlight the monocentric characteristic of the city. Locational features, especially distance to CBD and to undersupplied public goods, such as core primary school and shopping mall are significantly capitalized into price. Economic and demographic factors, including population density, per capita purchase power (proxy of rich or poor neighborhood), and per capita fixed investment (both flow and stock, proxy of housing supply and infrastructure improvement) are implicitly capitalized into housing price. More findings from Level Model exercise reveal that subgroups defined by various unit sizes exhibit differentiated capitalization effects of the same determinants. This finding links unit size with housing product, subsequently with various demographic structures. It again reinforces the idea

that demographic characteristic of one street block is key determinant of housing unit price. The results of Change Model actually reflect the trend of the city's growth and the anticipation of the market. The city is expected to keep growing fast with more migrant in-flow. Housing is going to be continuously undersupplied. And the development of infrastructure and locational amenities are believed to be always scarce and unevenly distributed in the near future. Such expectations build up market anticipation that locations inherently with good spatial features, hence high unit price will continue to be valuable and more expensive in time. In general, Change Model exhibits a firm belief that demand always outpaces supply in Chengdu.

Quantitative analyses in combined with qualitative discussion from local market experts are meaningful in practice. As stated in Section1.1, in China households spending large share of disposable income on housing not only look for place to live but also consider it long term family investment. The findings are useful guidelines to select housing location. The results of Change Model can be valuable criteria to determine short / long term investment in various types of housing products. The reports are also referable to developers who need to make careful assessment on developable land. The valuation is not only to determine its present value but more importantly to identify its potential growth. The steep gradient of price capitalization by some locational amenities and public can direct policy maker to enact specific movement in the effort to improve the city's infrastructure and amenities, and to strike for a more balanced urban structure between housing and jobs. The result of research, especially capitalization effect of spatial features will further assist local government determining land value more accurately before it is released for public bidding. Since most of infrastructure and public amenities are

financed by local government in China, it is critical to sell land closer its true market value accounting for both present and future capitalized price by a broad range of locational amenities.

Study of housing price dynamics in China is an interesting yet challenging exercise. The country is developing so fast and is constantly trying to solve so many issues concurrently. Some say that China by itself is an enormous social laboratory unprecedentedly in human history. Everyday researcher and scholar encounter fresh topic to discuss, innovative idea to explore. No single answer or static analysis can give ultimate answer to dynamic question in an ever-changing country like China. What determine housing price difference cross section and what determine housing price movement in time? The exploration to answer the questions doesn't end here. What are found in the thesis should be constantly reviewed, refined and enriched over time. To further extend the exercises, scholar and researcher should be astute, open-minded, and most importantly to integrate knowledge and skills cross social, cultural, economic, demographic, urban, econometric and many more disciplines.

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