Changing Spatial Structure of Major Chinese Cities

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

at the

Massachusetts Institute of Technology

September, 2015

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ABSTRACT

This paper examines the spatial structures of commercial real estate buildings (Offices, Retails) in four Chinese cities: Beijing, Shanghai, Shenzhen, and Guangzhou. In contrast to previous studies, this paper focused on the changes of the spatial pattern by involving the time variables to categorize the buildings into 3 time periods (Before 1995, 1996-2005, and 2006-2015). The research questions are: How strong and general is the tendency of offices and retails to cluster? At which spatial scale these clustering occurs? How does the clusters change with time? To test the localization in those cities, I applied distance-based agglomeration measures developed by Gilles Duranton and Henry G. Overman (2004) in this largely new context – to measure spatial structure in different time period at the metropolitan scale, which avoid problems relating to scale and borders. I find that: (1) Agglomeration forces cause offices to cluster in all of the four cities, but the clustering is much weaker in retails than offices. All four cities exhibit some localization in both types of real estate products. (2) With the development of cities, the clustering scales for all of the four cities are expanding. (3) There are some differences in the spatial structures among the four cities, the reasons might relate to the functions and the development stages of each city. Overall, the more mature a city's real estate market is, more dispersal spatial pattern is observed. (4) With the expansion of cities, the sizes of shopping centers and offices are increasing, too, especially between year 2006 and 2015.

Thesis Supervisor: William Wheaton
Title: Professor of Economics

ACKNOWLEDGEMENTS

This thesis will not become a reality without the help of so many people in so many ways. I would like to express my deepest gratefulness to all of them.

First and foremost, I want to thank my advisor Professor William Wheaton (MIT Department of Economics) whose expertise, consistent guidance throughout the whole summer that helped me bring this study into success.

I would like to thank Daniel Sheehan (MIT GIS Lab), for his constant guidance in the programming part.

I would also like to thank the director of Centaline China Research Center, Mr. Yuan Liu for his constructive comments, suggestions and generous sharing of data.

Special thanks to Professor Albert Saiz, Professor David Geltner, and Tricia Nesti, the MIT CRE faculties and staff who have willingly helped me out with their abilities.

Finally, I would like to thank my dear parents, Chengming Xu, Tu Hua who encouraged my decision to attend MIT, and supported me during all these years.

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Chapter 1. Introduction

1.1 Purpose of the thesis

Since 1990s, the real estate market has been experienced a rapid development in China, due to the very first Affordable Housing Management Regulation published at central level in 1994. After mid-90s, fast growth of real estate market and economy market both lead to the great changes in the location and spatial characteristics of retail and office properties.

Metropolitan-level centralization is usually driven by the agglomerative forces of industries - technology sharing, customer/supplier interactions and labor pooling. The metropolitan-level decentralization in China, however, is always driven first by the local government. To reduce the traffic jam, overcrowded city center and to lower the cost of land, local governments can adjust the situation by controlling the supply of lands. The business technology, especially the information technology also plays a significant role in changing the spatial patterns.

This paper provides an analysis of the patterns and processes of changes in the centralization and decentralization trend in different time periods in several major Chinese cities. The analysis of those four cities highlights both the regional characteristic in urban development and the common trends China.

1.2 Research motivation

The motivation of choosing this topic is to study cities from a real estate perspective. The spatial structure of a city has not only great value in academic research, but also can well applied into the practical fields in guiding investors to find the potential location.

In China, the mass development happened within a comparatively shorter time period than other countries. Moreover, in the past two decades, the improvement of technology, especially the internet technology, has profoundly changed how we behave and get work done, and increasingly while on the go.

In the traditional economics, markets are separated and are thus limited by space and time, but in the new form of internet platform, businesses are expanded at significantly low costs, leading to a result that super successful companies can reach the whole world' market in one specific field. The mainly reason for people to work together switches to the exchange of information, both face-to-face and electronically. Office and Retail cluster, as an important description of city patterns, reflects a characteristic of new economic growth space after this urban economies transformation.

Form a developer's perspective, it's worth thinking about the opportunities hidden behind all these challenges, so to study the trend of spatial structure in the new economic system is meaningful for further analyzing and forecasting on potential products and their locations.

1.3 Research methodology

On the basis of the locations of offices and retails in Beijing, Shanghai, Guangzhou and Shenzhen in three time periods (Before1995, 1996-1995, 2006-2015), this paper mainly uses the Kernel method modified by Duranton and Overman in 2004, which uses the distance instead of location to measure the localization so that to make comparison between different industries possible.

The Duranton & Overman methods allows us to assess the statistical significance of departures from randomness and treat space as continuous instead of using an arbitrary collection of geographical units. So that the scale and borders problems are avoided.

In Chapter 4, I map the spatial patterns in different cities with the GFA (gross floor area) in each building. In Chapter 5&6, I use the Duranton & Overman Kernel method to measure the localization and co-localization in different time periods in each city, and at which spatial scale the clustering occurs. In Duranton & Overman's Kernel method, the K-density variables are comparable across different time periods. This thesis controls the scale of the buildings (within the boundary of the city), the degree of clustering and the agglomeration of the whole time scale.

This paper uses the ArcGIS 10.2.2 to map the real distribution and create the randomness pattern, uses Python and Mat lab to do the Monte Carlo.

Chapter 2 Literature Review

2.1 Localization Theory

In the late nineteenth century, Alfred Marshall initially identified the benefits of clusters and industrial districts in his book Principles of Economics (1890), which economists have referred to as "agglomeration economies". There are 3 main sources of agglomeration externalities, which were first analyzed by Marshall and later rediscovered by Kenneth Arrow and Paul Romer as the Marshall-Arrow-Romer (MAR) externalities: the saving on transportation costs for suppliers, the creation of pools of specialized workers, the exchange of information and knowledge. Ellison Glenn and Edward L. Glaeser (1997), developed a K-density model to test geographic concentration in U.S. manufacturing industries by comparing observed levels of industry clustering with would be expected to arise randomly, and raised new indices of geographic concentration. In Ellison and Edward's method, three criteria were raised for measuring industry concentration: The measure is comparable across industries, and controls for both the overall tendency of manufacturing and for the degree of industry concentration.

Gilles Duranton and Henry G. Overman(2005) argued that, in an industry without clustering, the location of patterns will be determined by purely idiosyncratic factors, which would not necessarily form a regular patterns so that it will confuse the unevenness with industrial concentration. They also argued that the previous method cannot compare results across different scales. To solve the problem, Duranton & Overman(2005) proposed two additional criteria: The measure should be unbiased with respect to scale and spatial aggregation, and the significance of the test should be reported.

The use of K functions (the cumulative of K-densities) to define the density and the use of homogeneous spatial Poisson processes to generate counterfactual are widely accept in quantitative geography (Ripley, 1976; Cressie, 1993). Duranton & Overman innovatively developed the K-density approach instead of K function to involve more information for scale of location, and they set counterfactual from sampling randomly from a set of sites that involves the overall distribution of the industry.

In Duranton & Overman's method, it uses the distances between observations rather than the aggregating observations within administrative units, so that the indices can be calculated in continuous space. They uses Monte-Carlo approach to create statistical significance of departures from randomness. Details of Duranton & Overman's K-density approach are describe in chapter three.

The mainstream academic discussion about Chinese spatial structure are usually from an aspect of policy making and urban planning, most of which focus on one specific city and industry. The methods being used are thus mainly from classic theories in urban planning and geography, such as Central Space theory (W.Christaller), Losch Theory (August Losch), and Theory of Teriary Activity (Berry B. and Garrison). However, in this thesis paper, I want to step back from theoretical concerns and to consider some basic points in analyzing a city: How strong is the tendency of commercial real estate projects to cluster and how does they perform in different time period? At which spatial scale these clustering occurs? Duranton & Overman's K-density approach can be well applied to our research, they briefly mentioned that "this distance-based analyses can be applied beyond industrial geography. Any data with detailed geography information readily lends itself to this type of analysis."

Considering the spatial clustering problem from the real estate development aspect is a little different from industry. The supply of Chinese commercial real estate is usually strictly controlled by local policy makers, moreover, the retail and offices operation is different from manufacturing industry. However, the three agglomeration externalities remain: transportation costs, labor pool and exchange of information and knowledge are still the main concerns for the tenants, although the degree of attention for each points changes.

2.2 Polycentric City Theory

Within a particular city, the value of land in different location usually varies dramatically, most of which depends on the proximity to the central business district (CBD). Ever since 1960s, the monocentric city model was developed to describe the resource allocation in a city. This model is assumed to have a single and fixed-sized center of production activities with the entire city's work force employed there. The earliest papers are by William Alonso (1964), Richard Muth (1969), and Edwin Mills (1972), Alonso initially introduced bid-rent in his research as a function of the distance from the city center and the utility level of the household or firm, which was later widely adopted in urban economic.

But with the improvement of transportation technology and the emergence of the new economy, cities become increasingly polycentric, there appeared many attempts to modify and improve the monocentric city model. David L. Greene (1976) was among the earliest scholars to discuss the existence and significance of employment concentrations out of CBDs of large metropolitan cities. Bruce W. Hamilton (1982) examined the monocentric city model by comparing the predicted mean commuting distance with the actual data, and found the monocentric assumption underestimates eight times of a real-world commuting distance.

The polycentric city theory gradually appeared with its assumption of multiple population and/or employment density peaks. Daniel A. Griffith (1981) developed a multi-centered model by involving multi-centered density gradients and externalities among locations which presented a good fit for metropolitan Toronto. Masahisa Fujita and Hideaki Ogawa (1982) formulated an equilibrium model of non-monocentric urban land use and observed catastrophic structural transaction of the urban configuration. Gordon Richardson and Wong (1986) examined the distribution of population and employment in Los Angeles, and concluded that as population becomes more dispersed, the density peaks tends to disappear. Daniel P. McMillen and John F. McDonald (1997) demonstrated that the locally weighted regression estimates, which was developed by Cleveland and Devlin (1988), are better than ordinary least-squares in modeling polycentric cities, and applied the methodology to Chicago. They demonstrated that the agglomeration economies also applies in suburban area: "Employment groups together in a way that cannot be explained simply by access to the transportation network".

W. C. Wheaton (2002) developed a "Mix land use" polycentric city model, assuming jobs, commerce and residences can be spatially interspersed. This model demonstrates the dispersal of employment can greatly reduce commuting costs and in turn residential land rents, and accommodates urban grows to little or no increase in commuting cost and Ricardian Land Rent, which does consist with US cities. According to Wheaton's polycentric model, job dispersal would lead to both lower commuting costs and travel distances.

Chapter 3 Methodology & Data Collection

3.1 Methodology: Kernel Method

This paper uses GIS (Geographic Information System) to present and analyze the inventory data. This paper mainly follows Duranton and Overman, who proposed using the distance instead of location to measure the localization to make comparison between different industries.

In this thesis, the main purpose is to compare between different time periods: instead of comparing between different industries, we tried to normalize the distance in each time periods within every cities. Our steps of doing the Kernel Density Analysis are as below:

1. Get the original geo-coded data in Beijing, Shanghai, Guangzhou and Shenzhen with year build and separate the data within each city into three time periods.

2. Find the bilateral distances between pairs of points in the map in each time periods within each city and estimate a smoothed probability density for those bilateral distances using a kernel function.

3. Generate counterfactual probability densities by randomly map data within the boundary of each city in different time periods.

3. Find the bilateral distances between pairs of points and estimate a smoothed probability density for those bilateral distances using a kernel function.

4. Use the counterfactual distributions to create various tests of "significant" localization or dispersion.

3.2 Estimating densities

In city A with n buildings, we calculate the Euclidian distance between each pair of buildings, which generates $\frac{n(n-1)}{2}$ unique bilateral distances.

As noticed by Duranton & Overman, there are two sources of systematic error, one is that the curvature of the earth makes the Euclidian distance just a proximity of true physical distance of between buildings, another is that in areas with low density of roads, the actual journey distance might be much larger than the Euclidian distance, while in areas with high density of roads, the Euclidian distance would be a good proximity of actual journey distance, but also will be more congested. For the first source of systematic error, because our data are compared within a city, even the maximum possible error caused by the curvature of the earth will be very tiny, we just leave it as random errors. For the second, we follow Duranton & Overman's method to use a kernel-smooth when estimating the distribution of bilateral distances.

The K-density at distance d is:

$$\hat{K}(d) = \frac{1}{n(n-1)h} \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} f\left(\frac{d-d_{ij}}{h}\right) \quad (1)$$

Where n is the number of establishments, f is a kernel, h is the window width or bandwidth, and d_{ij} is the distance between buildings i and j. (as presented in section 2.4 of Silverman, 1986). For the kernel function, this thesis chose Gaussian basis functions, and h is calculated as following:

$$h = \left(\frac{4\hat{\sigma}^5}{3n}\right)^{\frac{1}{5}} \approx 1.06\hat{\sigma}n^{-1/5} \quad (2)$$

3.3 Generating counterfactuals

Then we need to generate relevant counterfactuals to which the K-densities for actual data be compared. This paper uses Monte Carlo simulations to identify the departures for each pair of distances from the randomness.

This paper uses Python in ArcGIS 10.2.2 to create random points to randomly generate a specified number of points (The same number with the real buildings built within that time period) within each within each city and calculate bilateral distances between each pairs of random points. For each test, 1,000 of these simulated location patterns (i.e. counterfactuals) are drawn, and K-densities for the counterfactuals are constructed in the same manner as before. These densities are later used to create local confidence intervals for the actual K-density we calculated earlier.

3.4 Constructing tests

There are two kinds of tests proposed in Duranton & Overman that give complementary information, in this thesis we use the local test which tests the localization of buildings within each city in different time periods.

I construct local confidence intervals at each 1 km in the distance interval 0 ≤ d ≤ 50 km, because we simply assume d>50 to be disperse. The sum of densities of the real distribution should be one over the entire range of distance, but our analysis is restrict to the interval [0, 50].

The null hypothesis is

H0: For any property type p in city A, ∀ d ∈ [0, 50], $\hat{K}_{Ap}(d) \sim \Psi_{Ap}(d)$;

Where $\Psi_{Ap}(d)$ is the distribution of K-density for random generated counterfactuals in city A for property type p.

I rank the 1,000 counterfactual densities at each of these distances d separately and take the 5th percentile $\underline{K}_{Ap}(d)$ and 95th percentile $\overline{K}_{\mathrm{Ap}}(d)$ as the 5% confidence interval at d. When for any property type p and any city A, $\widehat{K}_{Ap}(d) > \overline{K}_{\mathrm{Ap}}(d)$, this property type in city A is said to exhibit localization at distance d at a 5% confidence level. Correspondingly, when $\widehat{K}_{Ap}(d) < \underline{K}_{Ap}(d)$, this property type in city A is said to be dispersion at distance d a 5% confidence level. Graphically, the localization or dispersion can be detected when $\widehat{K}_{Ap}(d)$ lies above or below the $\overline{K}_{\mathrm{Ap}}(d)$ or $\underline{K}_{Ap}(d)$.

3.5 K-density for measuring co-localization

According to Duranton & Overman's research, co-localization can be applied across industries that are dependent. To compare the differences between the 3 periods, I used the co-localization test. Assume there are n_{Ap} buildings in time period A for property type p, and n_{Bp} in time period B for property type p, let 1,..., n_{Ap} represents buildings in time period A, and 1+n_{Ap},..., $n_{Ap} + n_{Bp}$ represents buildings in time period B. Then the K-density of bilateral distances between all pairs of establishments, one from each industry, at distance d becomes:

$$\widehat{K}(d) = \frac{1}{n(n-1)h}\sum_{i=1}^{n_{Ap}}\sum_{j=n_{Ap}+1}^{n_{Ap}+n_{Bp}} f\left(\frac{d-d_{ij}}{h}\right) \qquad (3)$$

For the counterfactuals, I simply use the same method as my localization analyses.

3.6 Data Collection

The data is from a complete survey of buildings by type (retail, office) which includes square feet and year built and is geo coded in Beijing, Shanghai, Shenzhen and Guangzhou, the survey was conducted in the beginning year of 2015 by Centerline Holding Group (China Research Center).

It should be noticed that since there were certain number of old buildings demolished each year, the survey data cannot cover every building that were built. But it can, to a large extend, present the spatial structure of those cities.

Chapter 4. The Spatial Pattern

4.1 Shanghai

In Shanghai, in the past 20 years, the number of offices increased 10.83 times and retails increased 14.18 times; the total inventory of offices increased 35 times and retails increased 27 times.

Table 4.1.1: The number of office buildings built in different periods

		Before 1995	1996-2005	2006-2015	Total
Offices	No. of buildings	125	591	763	1479
	Total GFA (m^2)	2,784,373	21,131,293	71,115,953	99,738,699
	Average size (m^2)	22,275	35,755	93,206	67,437
Retails	No. of buildings	44	195	429	668
	Total GFA (m^2)	1,081,040	6,467,454	22,747,825	30,296,320
	Average size (m^2)	24,569	33,166	53,025	45,354

With the number of buildings increases and the scale of spatial patterns expands, the size of buildings also increases: For offices, the average size increased by 60% from 1996 to 2005, and 160% from 2006 to 2015; for retails, the average size increased by 35% from 1996 to 2005, and 60% from 2006 to 2015.

One reason might be the fast increasing demand from the rapid growth of economics and large immigration during this period, another reason might associate with the fast development of real estate market: Since around 2000, the asset price saw rapid increase in Shanghai, which motivated developers to purchase increasingly larger land to earn the increasing land value, and to reduce the marketing and management cost at the same time.

We can further get the weighted average commuting distance from each building to the city center as formula (3):

$$D = \frac{\sum d_i * g_i}{\sum g_i} \qquad (3)$$

Where the D measures the weighted average distance of a city, d_i is the distance from buidling i to the city center, and g_i represents the GFA of each building.

Table 4.1.3: The GFA weighted average distance to city center

Time	Office	Retail
Before 1995	5.348 km	3.314 km
1996-2005	12.450 km	10.843 km
2006-2015	15.521 km	18.833 km
2015	12.336 km	17.532 km

The city center in Shanghai is defined at (31.224343, 121.469189), which is at the cross point of Yanan Elevated Road and North–South Elevated Road.

Overall, retails have longer average distances from city center than offices, which matched the conclusion we can get from Charts4.1.1 to Charts 4.1.8. And the result mainly from the newly built retails in period 2006-2015, although retails had smaller distance than offices before year 2005, the following construction of large quantity of community centers which mainly near the location of residential changed the trend.

Chart4.1.1: Offices Before 1995

Chart4.1.2: Offices 1996 – 2005

Chart4.1.3: Offices 2006 – 2015

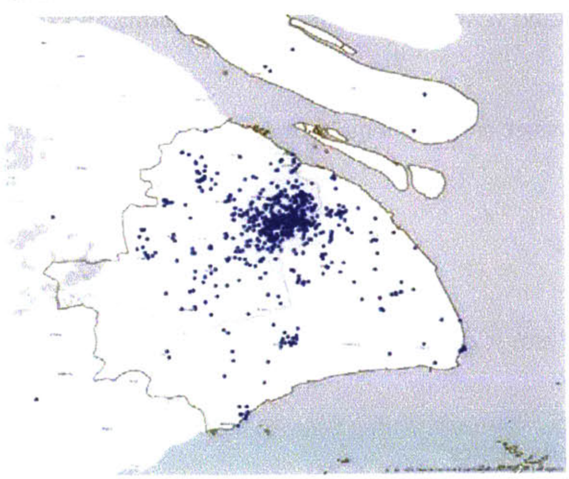


Chart4.1.4: All Offices in 2015

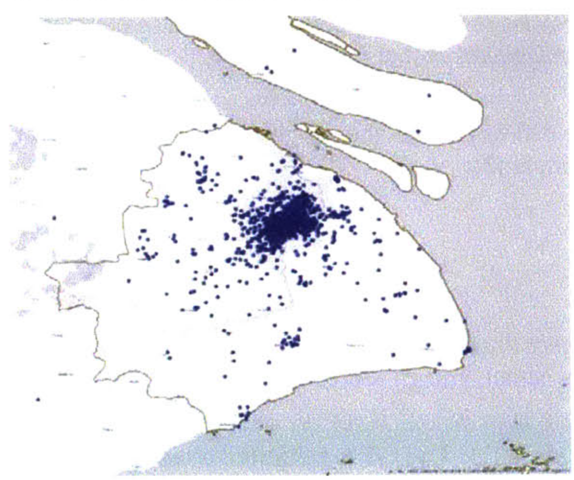


Chart4.1.5: Retails Before 1995

Chart4.1.6: Retails 1996 – 2005

Chart4.1.7: Retails 2006 - 2015

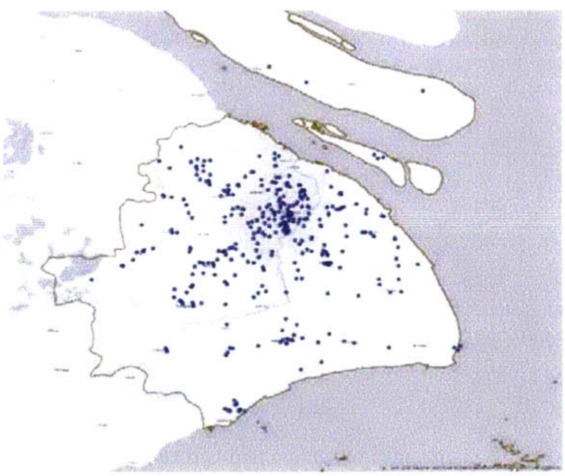
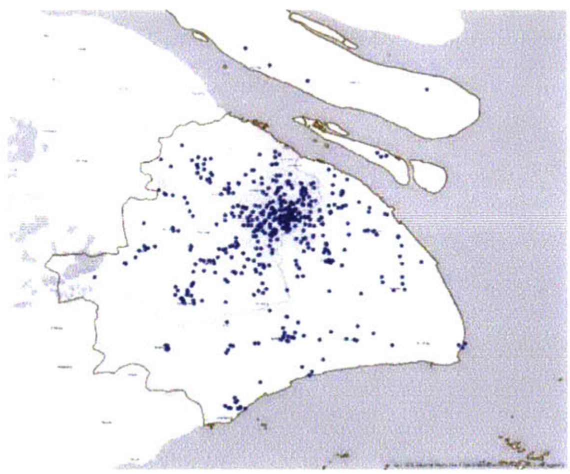


Chart4.1.8: All Retails in 2015



To focus on the density (the total GFA in each small area) of the distribution, I use ArcGIS to map the buildings by separate the map into 0.25 miles*0.25 miles grids (as our basic unit), and apply quantitative analysis to each unit. In each unit, I record the numbers of buildings, the sum of the GFA of every building. Thus, by using the grids, we can compare the density map of grids with the original map to find if the building is localized in a specific small area.

From Chart4.1.9 to Chart4.1.16, we can find the density map of the grids. We simply classify the grids into 5 ranges according to the GFA of each grid by using natural breaks. Then size of each point measures which rang the GFA of this area falls in.

Chart4.1.9: Offices Before 1995

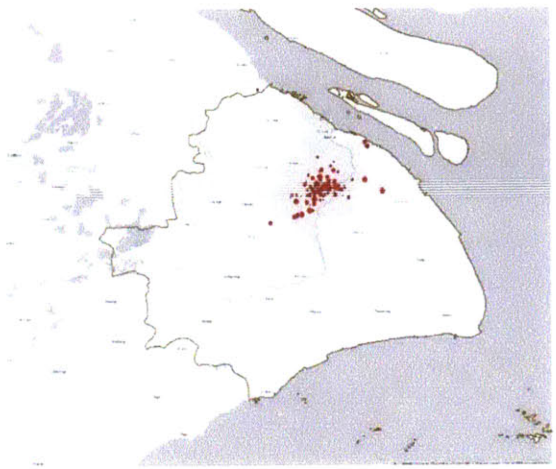


Chart4.1.10: Offices 1996 - 2005

Chart4.1.11: Offices 2006 - 2015

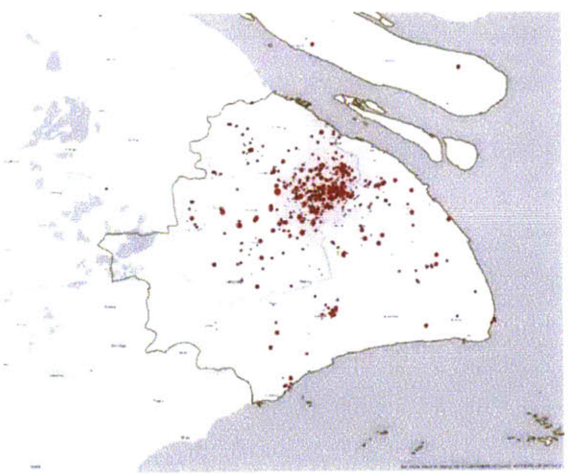


Chart4.1.12: All Offices in 2015

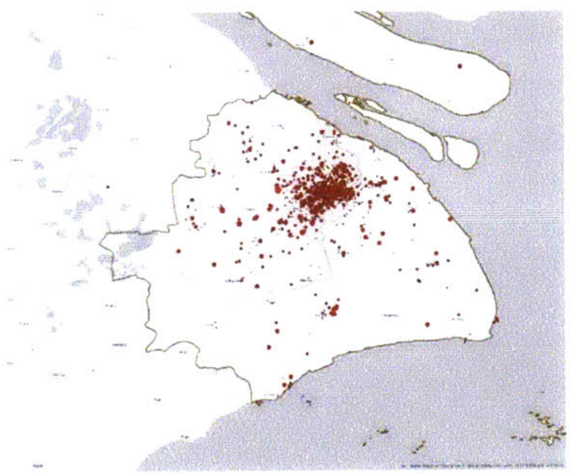
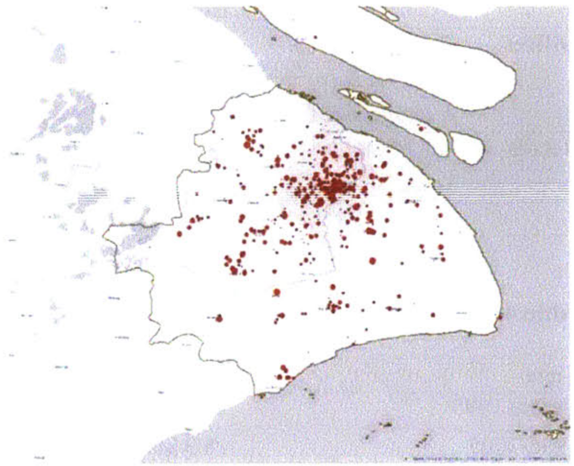


Chart4.1.13: Retails Before 1995

Chart4.1.14: Retails 1996 - 2005

Chart4.1.15: Retails 2006 - 2015

Chart4.1.16: All Retails in 2015



From those charts, we can find that retails are distributed more evenly than offices after 2005: there are not many small points, more grids are in the similar size than offices. Moreover, for both offices and retails, the distribution tend to be more evenly after 2005. For both type of buildings before 2005, large points tend to be located in the city center (although there are several exceptions in Shanghai offices before 1995), while after 2005, more large-sized buildings started to be located in the suburban area.

4.2 Beijing

Beijing commercial real estate market grows even more rapidly than Shanghai. In Beijing, in the past 20 years, the number of offices increased 39 times and retails increased 60 times; the total inventory of offices increased 144times and retails increased 46 times.

However, although the size of offices also increases, just as what happened in Shanghai, the size of retail do not change much. For offices, the average size increased by 176% from 1996 to 2005, and 67% from 2006 to 2015; for retails, the average size decreased by 20% from 1996 to 2005, and increased by 11% from 2006 to 2015.

The reason might be from the different function of the cities. Shanghai has been the business center of China even since before 1995, there is higher demand for large shopping and transaction centers in Shanghai than in Beijing. Many retails in Beijing are aimed at local customers, whereas retails in Shanghai are targeting customers in a larger scale. For offices, the increased size is probably for agglomeration benefits.

Table 4.2.1: The number and size of buildings built in different periods

		Before 1995	1996-2005	2006-2015	Total
Offices	No. of buildings	29	599	546	1174
	Total GFA (m^2)	764,204	43,704,937	66,487,235	110,956,377
	Average size (m^2)	26,352	72,963	121,771	94,511
Retails	No. of buildings	18	263	691	972
	Total GFA (m^2)	786,687	9,129,915	26,734,027	36,650,6299
	Average size (m^2)	43,704	34,715	38,689	37,706

Table 4.2.2: The GFA weighted average distance to city center

Time	Office	Retail
Before 1995	5.267 km	8.22 km
1996-2005	8.3 km	10.435 km
2006-2015	13.575 km	13.485 km
2015	11.440 km	12.650 km

The city center in Beijing is defined at (39.9252729, 116.3967232), the Jiangshan Park.

Similar to Shanghai, retails in Beijing have longer average distances from city center than offices, although the gap is not as large. This trend has been continued since before 1995.

Chart4.2.1: Offices Before 1995

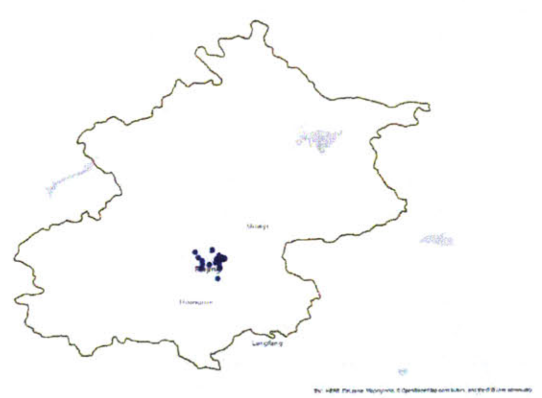


Chart4.2.2: Offices 1996 - 2005

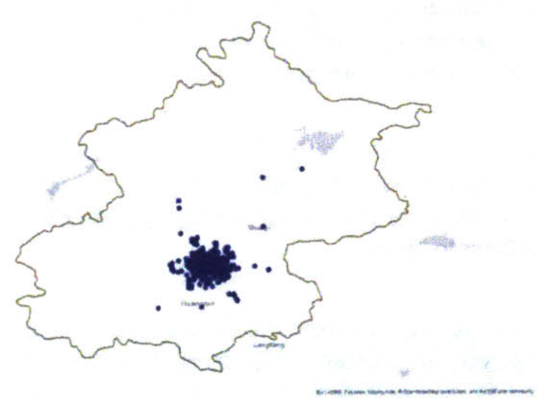


Chart4.2.3: Offices 2006 - 2015

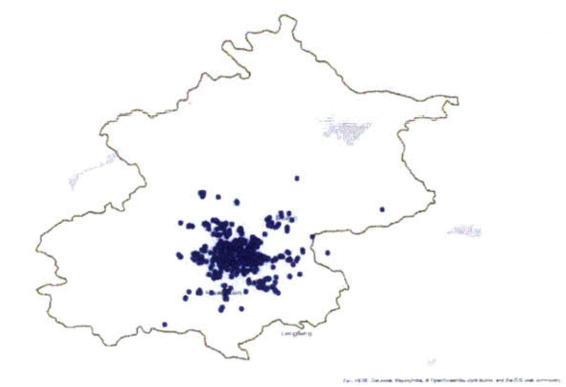


Chart4.2.4: All Offices in 2015

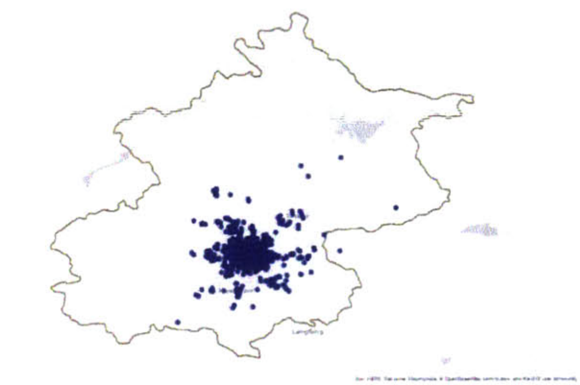


Chart4.2.5: Retails Before 1995

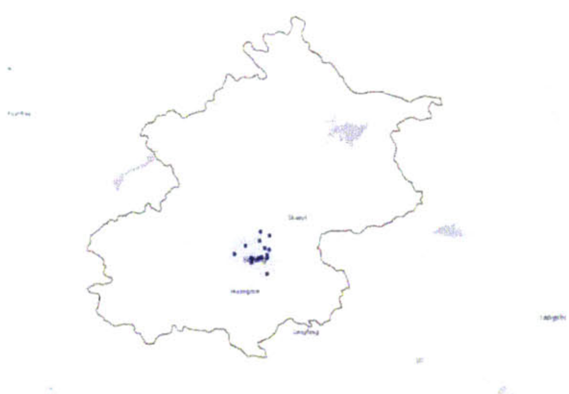


Chart4.2.6: Retails 1996 - 2005

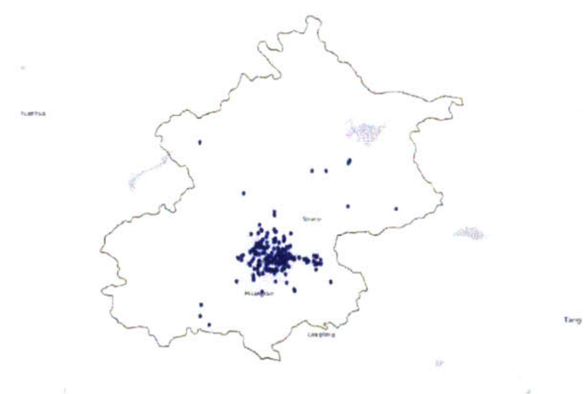


Chart4.2.7: Retails 2006 - 2015

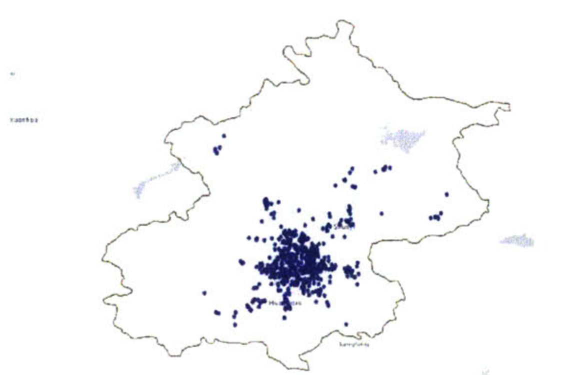


Chart4.2.8: All Retails in 2015

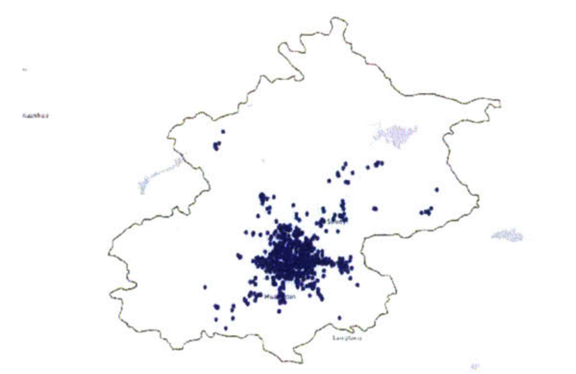


Chart4.2.9 to Chart4.2.16 are the map of the grids. Retails in Beijing are not as dispersed as Shanghai, for the retails market in Beijing started later. Even after 2005, there are still high portion of both types of buildings built in the city center, only small quantity of projects built in the suburban. Only when developers find it's too expensive to bid for lands in the city center (considering the transportation cost are extremely high in Beijing for its bad traffic) and the real estate demand in the suburban area started to grow rapidly will they move to the suburban. We might observe the obvious dispersal of retails in Beijing in the next 5 to 10 years, according to Shanghai's experience.

Chart4.2.9: Offices Before 1995

Chart4.2.10: Offices 1996 - 2005

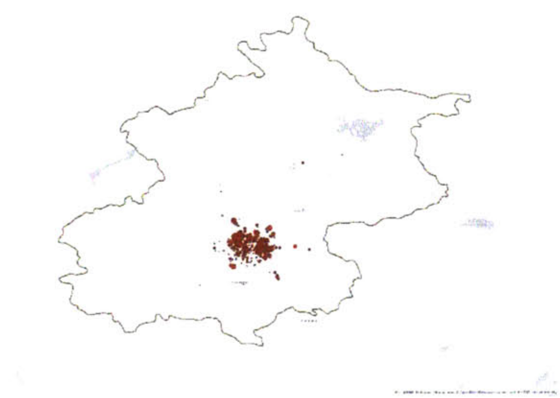


Chart4.2.11: Offices 2006 - 2015

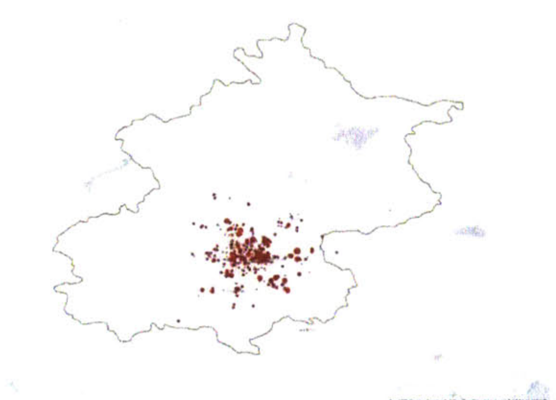


Chart4.2.12: All Offices in 2015

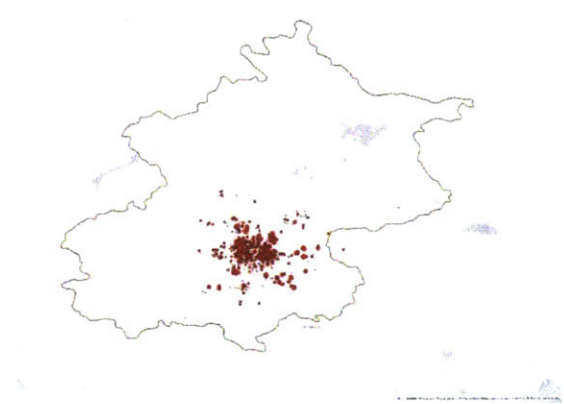


Chart4.2.13: Retails Before 1995

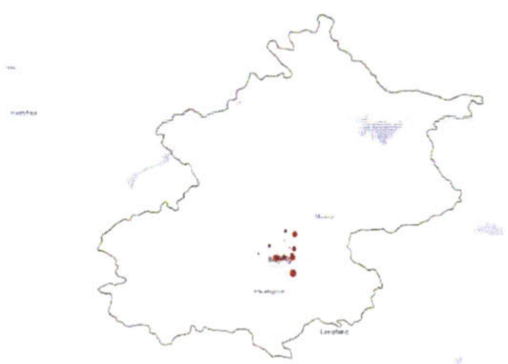


Chart4.2.14: Retails 1996 - 2005

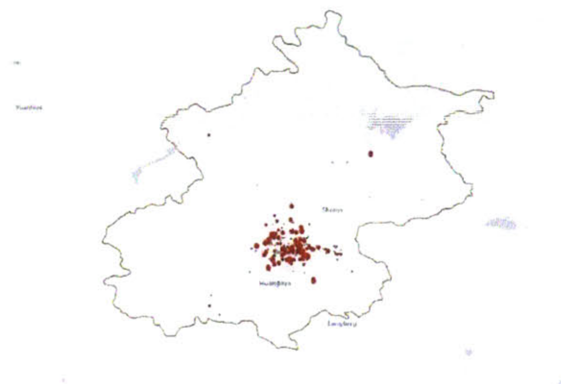


Chart4.2.15: Retails 2006 - 2015

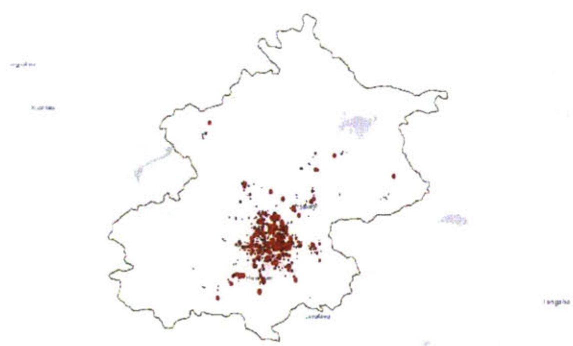
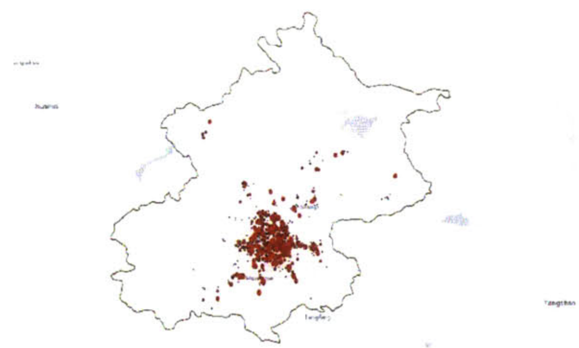


Chart4.2.16: All Retails in 2015



4.3 Shenzhen

Shenzhen commercial real estate market grows slower than the previous two cities. In the past 20 years, the number of offices increased 3.7 times and retails increased 39.57 times; the total inventory of offices increased 3.82 times and retails increased 80 times.

As the business center in south China, the trend of the changing size of retail is similar to Shanghai. For offices, the average size increased by 52% from 1996 to 2005, and 164% from 2006 to 2015; for retails, the average size increased by 32% from 1996 to 2005, and 99% from 2006 to 2015.

Table 4.3.1: The number and size of buildings built in different periods

		Before 1995	1996-2005	2006-2015	Total
Offices	No. of buildings	50	178	153	381
	Total GFA (m^2)	1,545,198	8,357,961	18,953,380	28,856,539
	Average size (m^2)	30,904	46,955	123,878	75,738
Retails	No. of buildings	7	131	146	284
	Total GFA (m^2)	135,300	3,349,272	7,457,323	10,941,896
	Average size (m^2)	19,329	25,567	51,078	38,528

Chart4.3.1: Shenzhen Offices Before 1995

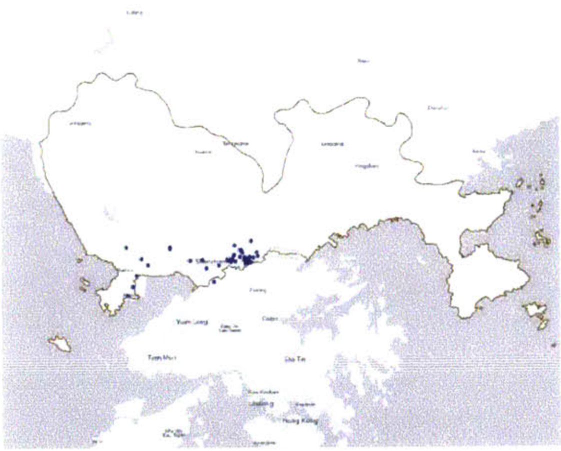


Chart4.3.2: Shenzhen Offices 1996 - 2005

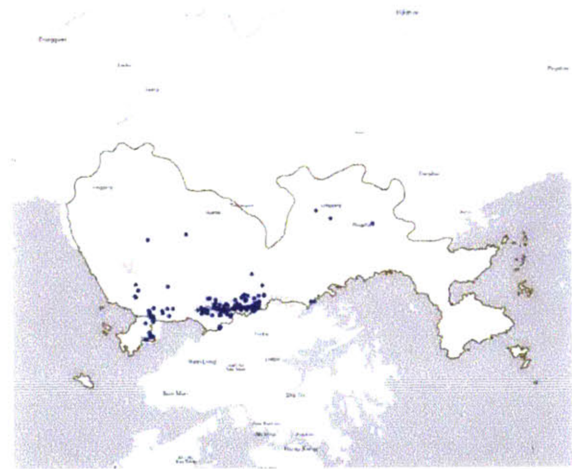


Chart4.3.3: Shenzhen Offices 2006 - 2015

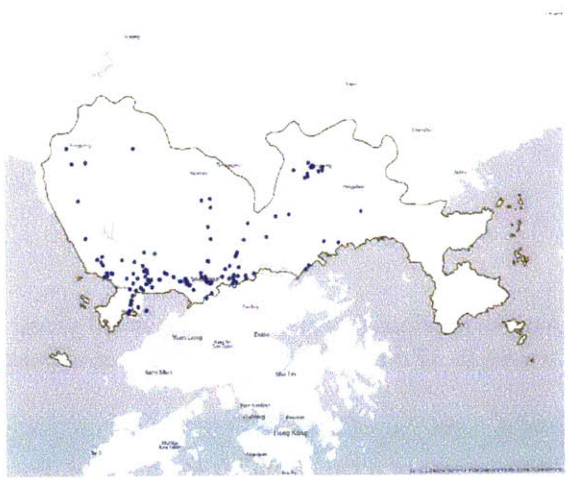


Chart4.3.4: Shenzhen All Offices in 2015

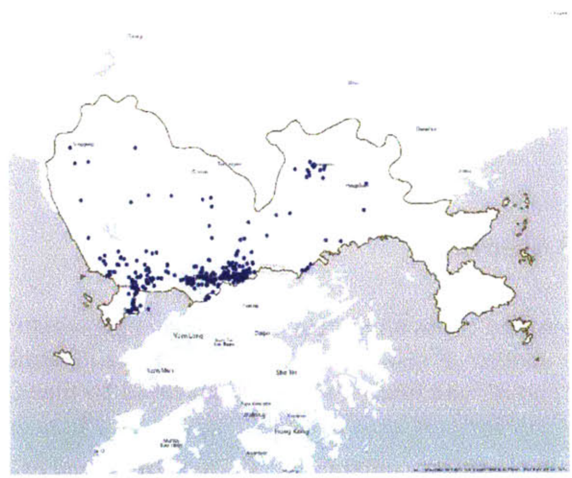


Chart4.3.5: Shenzhen Retails Before 1995

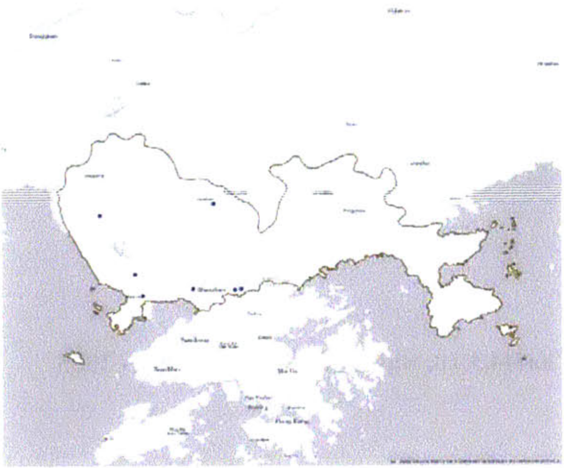


Chart4.3.6: Shenzhen Retails 1996 - 2005

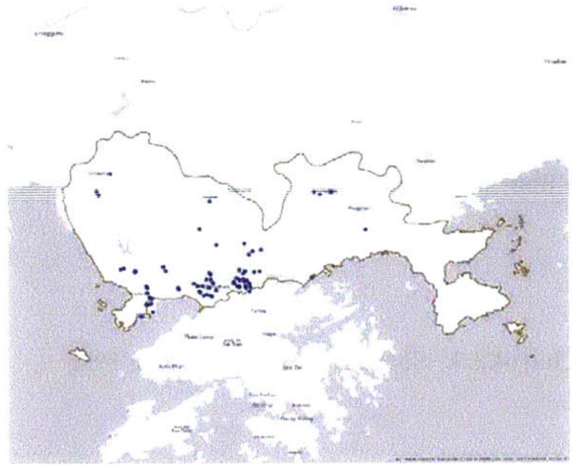


Chart4.3.7: Shenzhen Retails 2006 - 2015

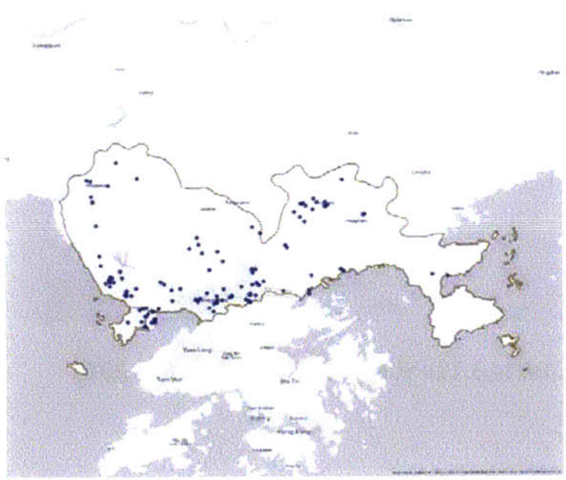
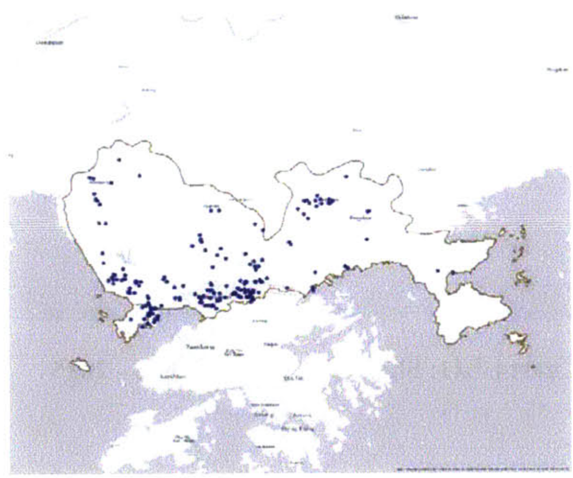


Chart4.3.8: Shenzhen All Retails in 2015



We set the city center of Shenzhen at (22.544213,114.0567376), which is the middle of 3rd Fuzhong Road. The average distance (weighted by GFA) from each building to the city center is as below:

Table 4.3.2: The GFA weighted average distance to city center

Time	Office	Retail
Before 1995	6.283 km	13.475 km
1996-2005	6.311 km	10.415 km
2006-2015	11.708 km	21.490 km
2015	10.964 km	18.971 km

Overall, retails in Shenzhen have much longer average distances from city center than offices. And the average distance both increased fastest in 2006-2015, so the large dispersion happened during this period and might continue in the future.

Chart4.3.9 to Chart4.3.16 are the map of the grids. The retails patterns in Shenzhen are quite similar with Shanghai, which is much dispersed, but not as dispersed. For offices, they are mainly clustered at south part of Shenzhen. Meantime, the clusters distributed more unevenly in Shenzhen than Shanghai and Beijing: some super large points appears.

Chart4.3.9: Shenzhen Offices Before 1995

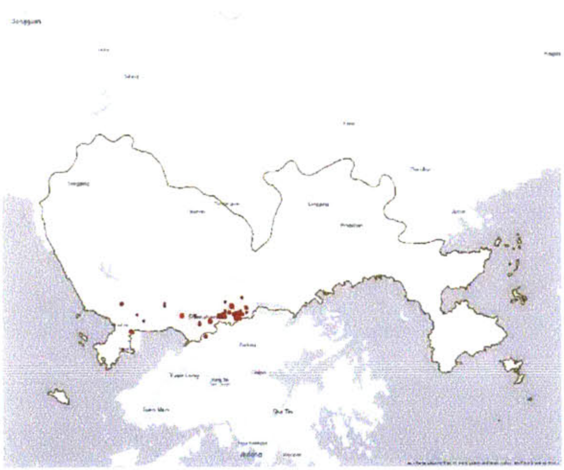


Chart4.3.10: Shenzhen Offices 1996 - 2005

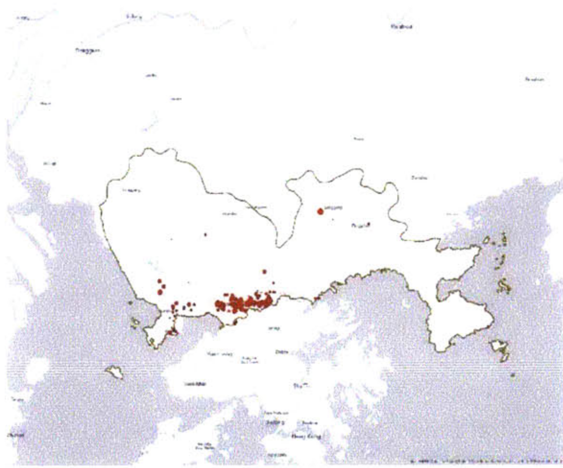


Chart4.3.11: Shenzhen Offices 2006 - 2015

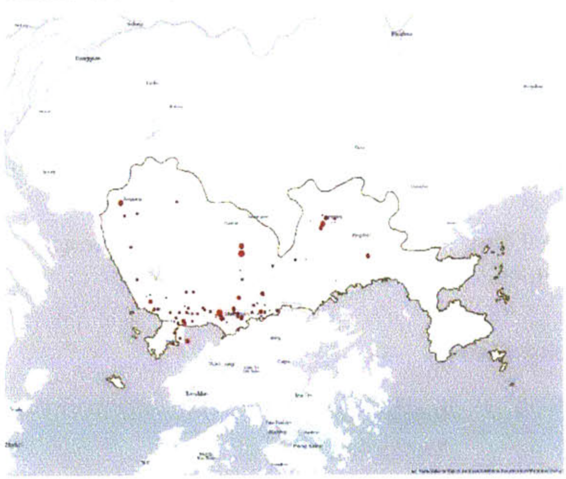


Chart4.3.12: Shenzhen All Offices in 2015

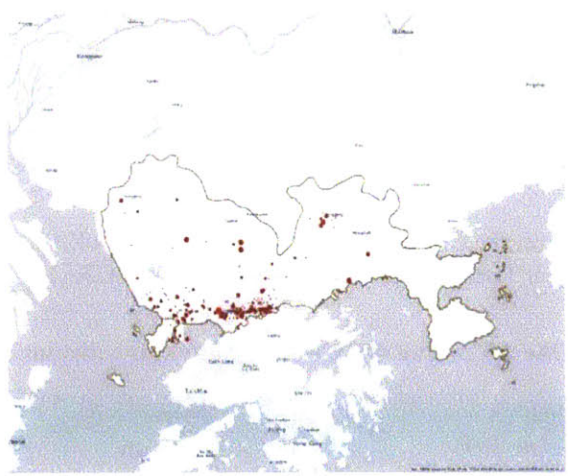


Chart4.3.13: Shenzhen Retails Before 1995

Chart4.3.14: Shenzhen Retails 1996 - 2005

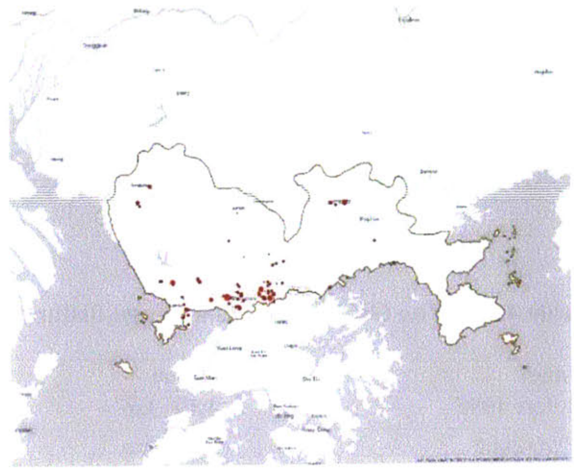


Chart4.3.15: Shenzhen Retails 2006 - 2015

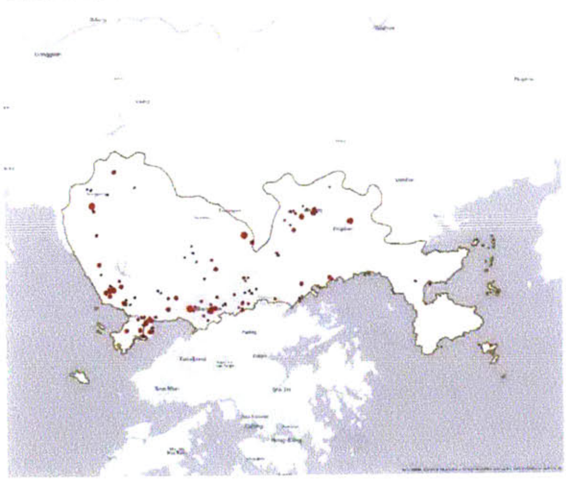
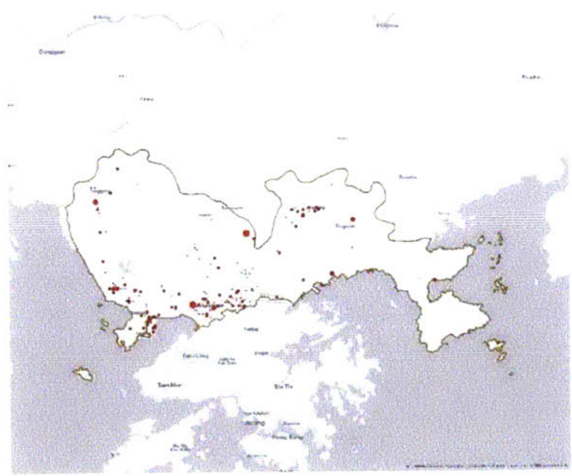


Chart4.3.16: Shenzhen All Retails in 2015



4.4 Guangzhou

In the past 20 years, the number of offices increased 10 times and retails increased 18 times; the total inventory of offices increased 17 times and retails increased 37 times. For offices, the average size decreased by 11% from 1996 to 2005, and 228% from 2006 to 2015; for retails, the average size increased by 43% from 1996 to 2005, and 75% from 2006 to 2015.

The city center of Guangzhou is defined at (23.1290423, 113.2648204), the 1 Fu Qian Lu.

Table 4.4.1: The number and size of buildings built in different periods

		Before 1995	1996-2005	2006-2015	Total
Offices	No. of buildings	53	319	209	581
	Total GFA (m^2)	2,140,952	11,415,670	24,537,521	38,094,143
	Average size (m^2)	40,395	35,786	117,404	65,567
Retails	No. of buildings	14	115	141	270
	Total GFA (m^2)	284,050	3,356,141	7,189,449	10,829,640
	Average size (m^2)	20,289	29,184	50,989	40,110

Table 4.4.2: The GFA weighted average distance to city center

Time	Office	Retail
Before 1995	4.191 km	4.692 km
1996-2005	7.338 km	6.804 km
2006-2015	12.072 km	15.785 km
2015	10.210 km	13.620 km

Chart4.4.1: Guangzhou Offices Before 1995

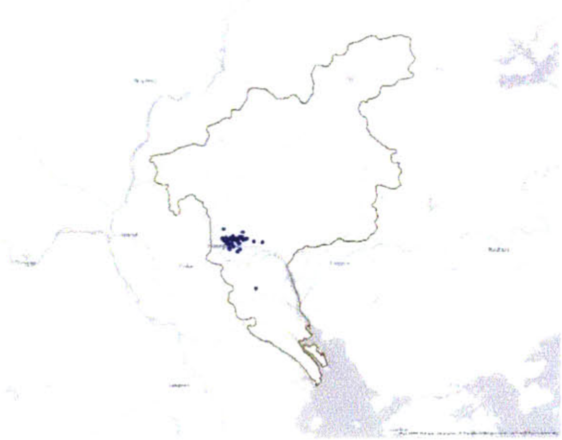


Chart4.4.2: Guangzhou Offices 1996 - 2005

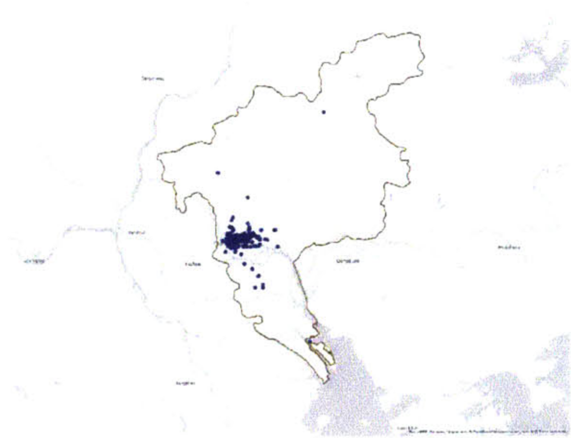


Chart4.4.3: Guangzhou Offices 2006 - 2015

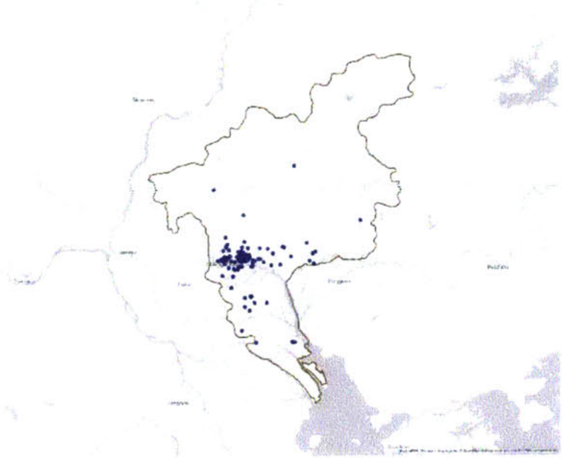


Chart4.4.4: Guangzhou All Offices in 2015

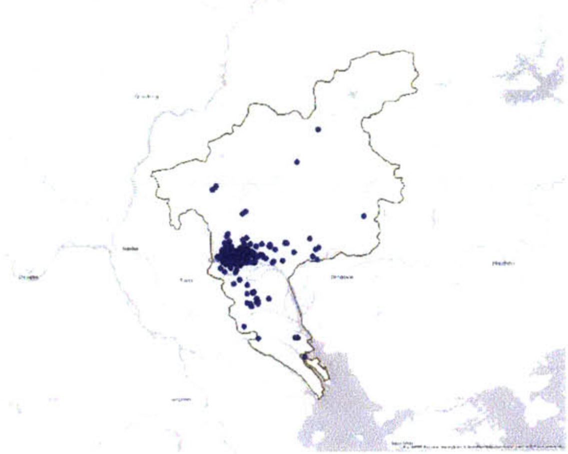
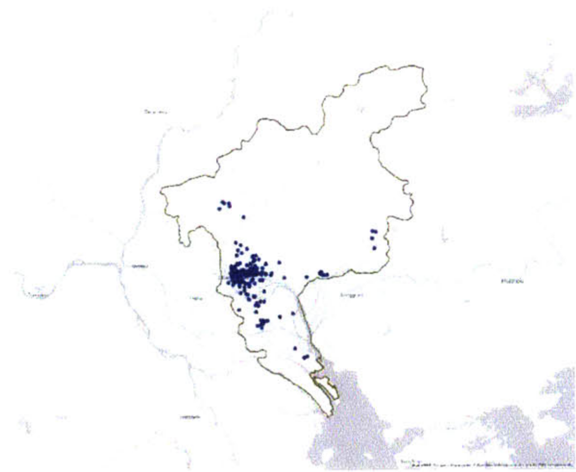


Chart4.4.5: Guangzhou Retails Before 1995

Chart4.4.6: Guangzhou Retails 1996 - 2005

Chart4.4.7: Guangzhou Retails 2006 - 2015

Chart4.4.8: Guangzhou All Retails in 2015



Similar to Shanghai and Shenzhen, retails in Guangzhou have longer average distance from city center than offices. For retails, the average distance increased fastest in 2006-2015, which can also be observed in Chart4.4.7. For offices, the dispersion also happened obviously, but not as much as retails.

From Chart4.4.9 to Chart4.4.1, we can find that the grids pattern is more similar to Shenzhen than Beijing and Shanghai. For offices, they started to expand after year 2006, and for retails, it looks much dispersed even after 1996.

Chart4.4.9: Guangzhou Offices Before 1995

Chart4.4.10: Guangzhou Offices 1996 - 2005

Chart4.4.11: Guangzhou Offices 2006 - 2015

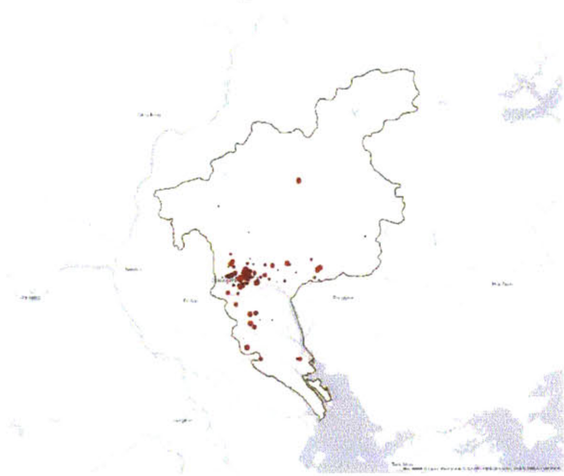


Chart4.4.12: Guangzhou All Offices in 2015

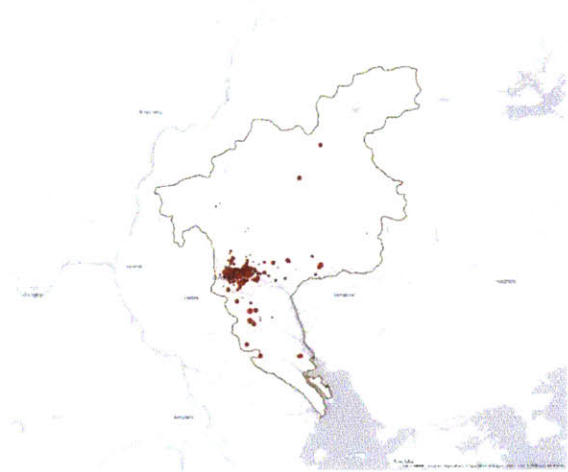


Chart4.4.13: Guangzhou Retails Before 1995

Chart4.4.14: Guangzhou Retails 1996 - 2005

Chart4.4.15: Guangzhou Retails 2006 - 2015

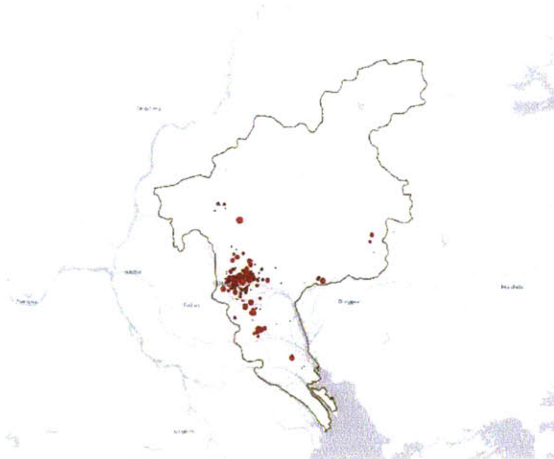
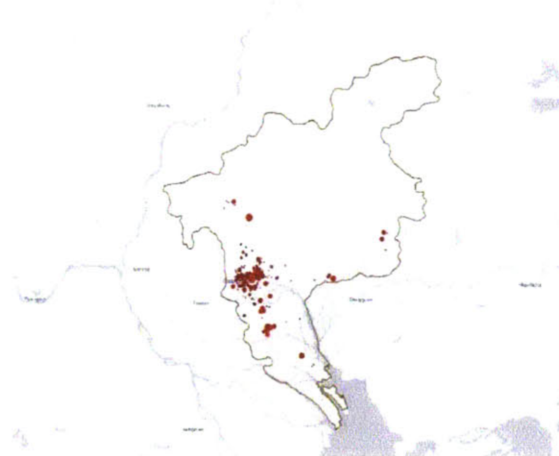


Chart4.4.16: Guangzhou All Retails in 2015



4.5 Differences between cities and product types

We should first notice that although overall, the trend of dispersal among the four cities are generally similar, there are still some obvious differences between cities and product types that need to be discussed.

First, the distribution of retails in Shanghai and Shenzhen looks very different from Beijing and Guangzhou, which are both more dispersed even in the early stage. The explanation might be the economic function of those two cities, both are defined as the regional central cities, having more connection with surrounding cities leads to more active business activities. Beijing, the capital of China, and Guangzhou, the capital of Guangdong Province, are both more conservative in expansion. Another point is from the development stage of the real estate market-the earliest successful developers are mainly from Guangdong province, for the influential from Hong Kong. In general, cities located in the South are developed earlier than the north.

Another thing that should make comments is the increase in the size of buildings in Shanghai, Shenzhen, and Guangzhou after 2005. To find out the reason for the increase, I list the average sizes and numbers

Table 4.5.1: The number and average size of retails in different periods

City	Time Period	Number of Retails	Average Size of Retails (m^2)
Shanghai	Before 1995	44	24569
	1996 - 2005	195	33166
	2006 - 2015	429	53025
Beijing	Before 1995	18	43705
	1996 - 2005	263	34715
	2006 - 2015	691	38689
Shenzhen	Before 1995	7	19329
	1996 - 2005	131	25567
	2006 - 2015	146	51078
Guangzhou	Before 1995	14	20289
	1996 - 2005	115	29184
	2006 - 2015	141	50989

in each city and time period. We can find that from 1996 to 2005, the largest portion of new built retails are shopping centers and independent stores in all the four cities, whereas from 2006 to 2015, the newly built retails in Beijing and Shenzhen changes to community centers which are built inside residential communities. That can explain the average retail size in Beijing did not increase, because in general, the size of community center is smaller than shopping centers.

From table 4.5.3, we can find that the average sizes of shopping centers in Shenzhen, Guangzhou and Shanghai have increased a lot in the past 10 years, whereas for Beijing, the size did not increase much, mainly because there are already some large–sized shopping centers before year 2006. This findings can largely explain the increase of average size in Shanghai, Shenzhen and Guangzhou. The sizes of community centers are generally around 10,000 to 20,000 m^2. There are also some increase in the average size of cinemas, theaters and commercial streets, the increase are quite random, mainly decided by special cases.

Table 4.5.2: The number of retails of different uses in different periods

City	Time Period	Cinema/ Theater	Commercial Street	Community Center	Shopping Center/Store	Supermarket
Shanghai	Before 1995	9	1		31	3
	1996 - 2005	1	34	58	69	33
	2006 - 2015		108	132	186	3
Beijing	Before 1995	2			13	3
	1996 - 2005	5	16	51	115	76
	2006 - 2015		128	258	243	62
Shenzhen	Before 1995		1		3	3
	1996 - 2005	4	6	6	59	56
	2006 - 2015	2	11	82	38	13
Guangzhou	Before 1995	6	1	1	6	
	1996 - 2005	7	17	9	45	37
	2006 - 2015	1	33	34	66	7

Table 4.5.3: The average size of retails of different uses in different periods (m^2)

City	Time Period	Cinema/ Theater	Commercial Street	Community Center	Shopping Center/Store	Supermarket
Shanghai	Before 1995	6944	10000		31921	6333
	1996 - 2005	70000	50075	16205	46988	15542
	2006 - 2015		69705	27394	62165	13667
Beijing	Before 1995	5944			57446	9333
	1996 - 2005	7655	49025	18825	59271	6987
	2006 - 2015		42116	23740	60743	7382
Shenzhen	Before 1995		12000		20000	21100
	1996 - 2005	4250	21500	29646	33886	18323
	2006 - 2015	6000	284122	16811	72881	13231
Guangzhou	Before 1995	3008	60000	15000	31833	
	1996 - 2005	8786	46118	7503	47980	7676
	2006 - 2015	7000	59533	19333	68036	10029

Chapter 5 Test and Results

5.1 Localization Introduction

In this thesis, localization is measured as the density of distance $\hat{K}$(d). If $\hat{K}$(d) is outside the confidence interval which generated by counterfactuals, we can conclude the buildings are localized or dispersed. Graphically, the localization or dispersion can be detected when the K-density of the distance lies above or below the $\overline{K}$(d) or $\underline{K}$(d).

5.2 Localization Measurement

We model spatial clusters by product type (Office & Retail). Our model highlights how agglomerative forces lead to connections among real estate projects while interaction costs generate a defined distance over which attraction forces operate. Kernel density estimates for our data are shown in chats 5.2.1-5.2.32.

Shanghai

For offices in Shanghai, as we discussed in chapter 4, the trend of localization was strengthen during 1996 and 2005 period, and weakened in the next 10 years. But retails are quite dispersed, which are presented as a much flatter K-density curve than the offices. There is no obviously trend of localization or dispersal.

For the total retails in 2015, the peak value of density is only 34% of offices (Table 5.2.1), even there are much more offices than retails (1479 vs 668). Retails in Shanghai tend to locate in proximity to residence rather than jobs, so they don't present a highly localized pattern as offices, although the localization still exists. As the city expands, retails become more and more dispersal.

Table 5.2.1: The buildings localization and the counterfactual

		Before 1995	1996 – 2005	2006 – 2015	Total in 2015
Offices	Localization area	[0,20 km]	[0,18 km]	[0,34 km]	[0,21 km]
	Peak distance	5km	6km	12km	6 km
	Peak value	2.48E-8	3.93E-10	9.56E-11	5.65E-11
Retails	Localization area	[0,8 km]	[0,13 km]	[0,7 km]	[0,5 km]
	Peak distance	8km	17km	26km	23km
	Peak value	6.92E-9	4.6E-10	6.11E-11	1.95E-11

Chart5.2.1: Offices Before 1995

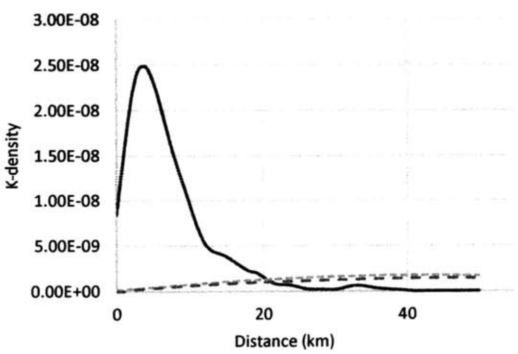


Chart5.2.2: Offices 1996 - 2005

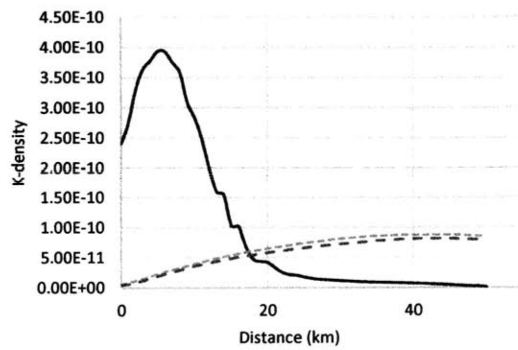


Chart5.2.3: Offices 2006 - 2015

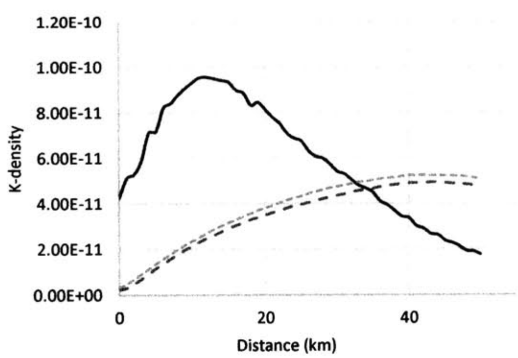


Chart5.2.4: All Offices in 2015

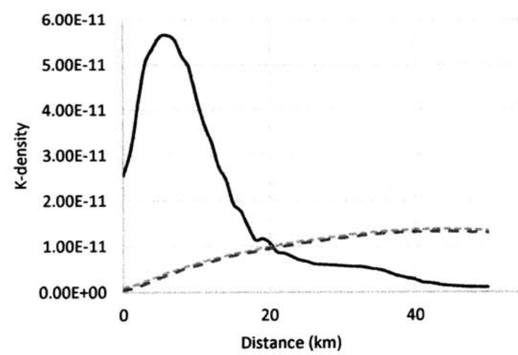


Chart 5.2.5: Retails Before 1995

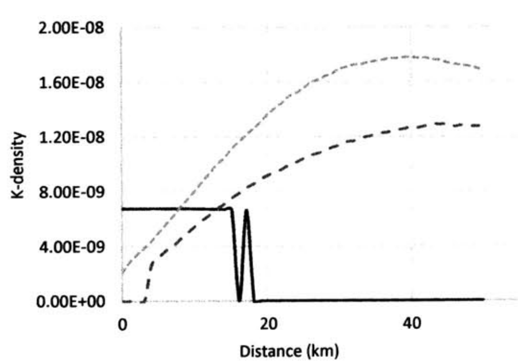


Chart 5.2.6: Retails Between 1996 and 2005

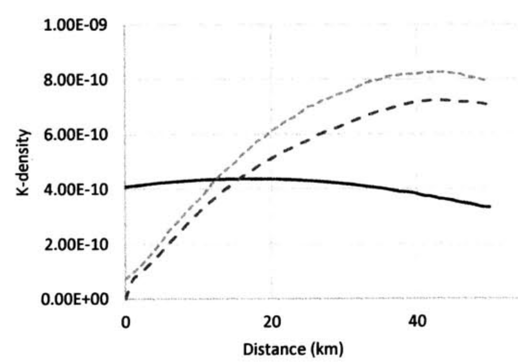


Chart5.2.7: Retails 2006 - 2015

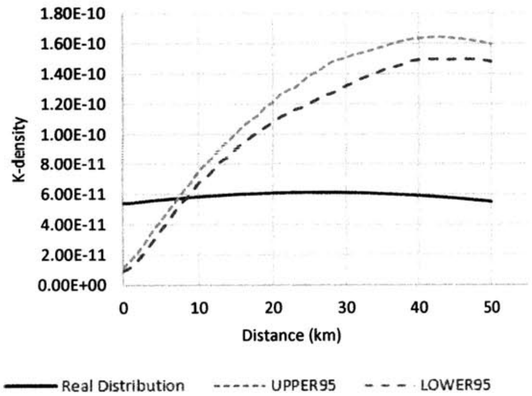
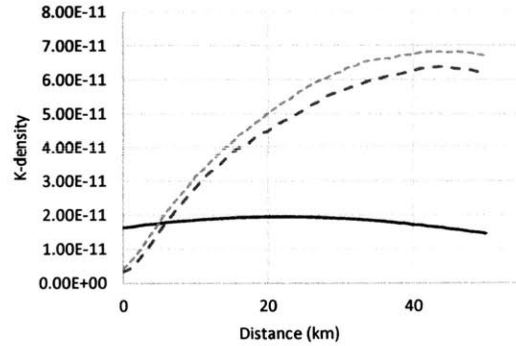


Chart5.2.8: All Retails in 2015



Beijing

For offices in Beijing, similar to Shanghai, the trend of localization was strengthen during 1996 and 2005 period, and weakened in the next 10 years.

But retails patterns are quite similar to offices, which is different from other cities. The clustering of retails in Beijing is very strong, for that in 2015, the peak value of retail density is quite similar to offices, even there are much more offices than retails. Beijing market started to grow very late, around after year 2009 when Beijing started to see fast increasing housing and commercial real estate price, which later leaded to the speed up of construction, 5 years later than Shanghai. The stage of Beijing in growing from monocentric to polycentric city is later than Shanghai, so we would see more dispersal patterns in Beijing in the following several years, especially when the central government planned a "subsidiary administrative center" at Tong Zhou district, aiming to promote the integration of Beijing with its neighboring Hebei province and Tianjin Municipality.

Table 5.2.2: The buildings localization and the counterfactual

		Before 1995	1996 – 2005	2006 – 2015	Total in 2015
Offices	Localization area	[0,15 km]	[0,22 km]	[0,35 km]	[0,21 km]
	Peak distance	4km	9km	14km	10km
	Peak value	2.5E-7	4.05E-10	2.4E-10	7.51E-11
Retails	Localization area	[0,21 km]	[0,23 km]	[0,32 km]	[0,30 km]
	Peak distance	9km	12km	12km	12km
	Peak value	5.35E-7	1.43E-9	1.63E-10	9.03E-11

Chart 5.2.9:Offices Before 1995

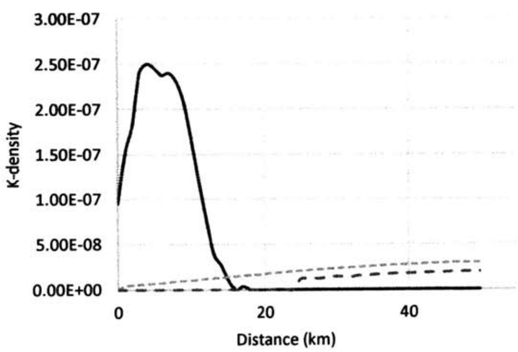


Chart 5.2.10: Offices Between 1996 and 2005

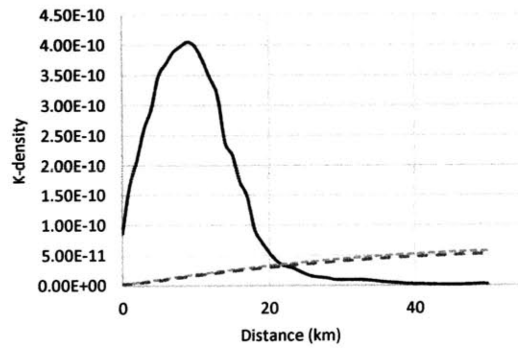


Chart 5.2.11: Offices Between 2006 and 2015

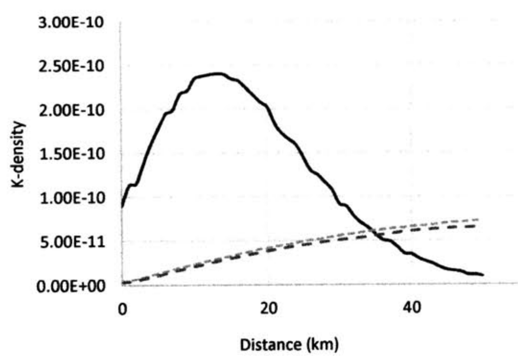


Chart 5.2.12: All Offices in 2015

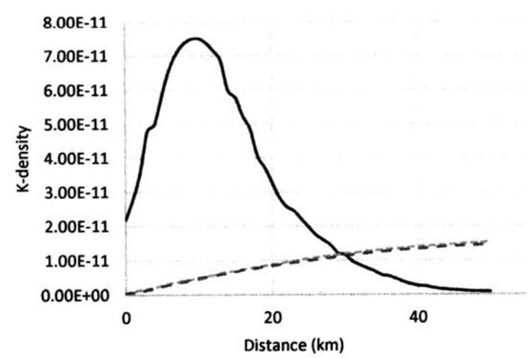


Chart5.2.13: Retails 2006 - 2015

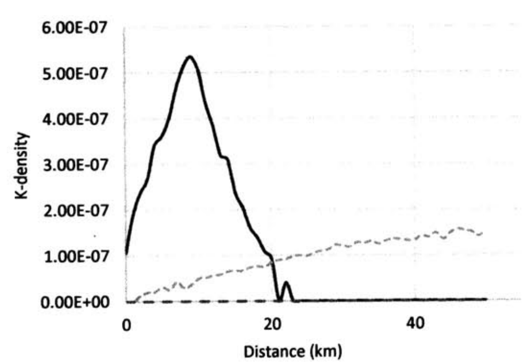


Chart5.2.14: All Retails in 2015

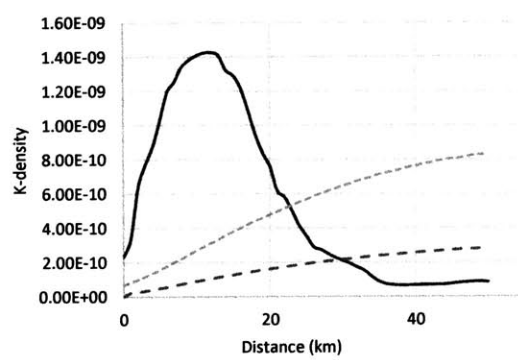


Chart5.2.15: Retails 2006 - 2015

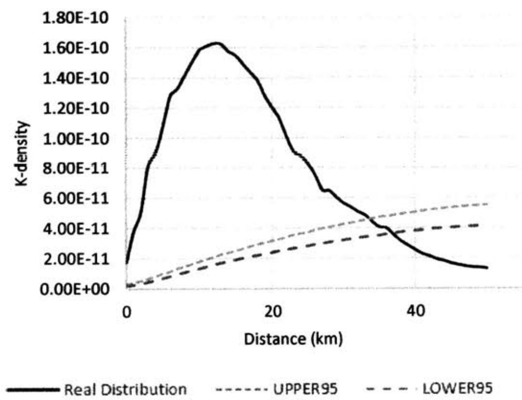
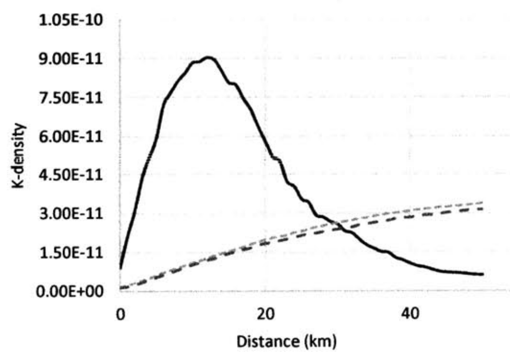


Chart5.2.16: All Retails in 2015



Shenzhen

For offices in Shenzhen, it's quite different from other three cities, especially when before 2006. The density curves of Shenzhen Offices are not as smooth as others, moreover, there are more peaks. The reason might be related with the geography factor. Shenzhen is located in the Pearl River Delta, bordering Hong Kong to the south, Lingding Yang (Lintin Sea) and Pearl River to the west and Mirs Bay to the east, so the CBD in Shenzhen are mainly developed along the coast, leading to a long stripe of offices along the water. But the trend of buildings to be more dispersed in Shenzhen is quite similar with other cities.

Retail patterns in Shenzhen are quite similar to Shanghai after 2006, and similar to the offices in Shenzhen before 2006. The clustering of retails is not obvious before 2005, since there are only a few, and was highly strengthened between 1996 and 2005. But after 2005, the curve becomes very smooth and flat.

Table 5.2.3: The buildings localization and the counterfactual

		Before 1995	**1996 – 2005**	**2006 – 2015**	**Total in 2015**
Offices	Localization area	[0,6 km]	[0,14 km]	[0,34km]	[0,18 km]
	Peak distance	3 km	3 km	9km	4km
	Peak value	1.71E-8	5.52E-9	4.6E-9	7.2E-10
Retails	Localization area	[0,26 km]	[0,15 km]	[0,36 km]	[0,36 km]
	Peak distance	20 km	10km	15km	15km
	Peak value	2.5E-6	6.32E-9	1.45E-10	8.17E-11

Chart 5.2.17:Offices Before 1995

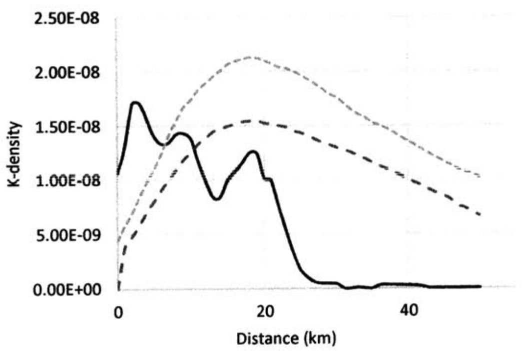


Chart 5.2.18: Offices Between 1996 and 2005

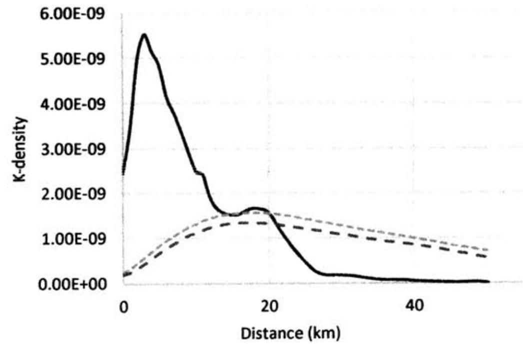


Chart 5.2.19: Offices Between 2006 and 2015

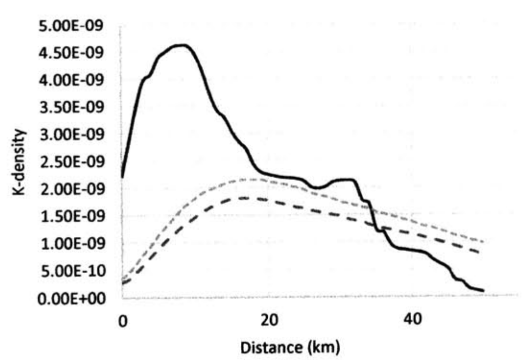


Chart 5.2.20: All Offices in 2015

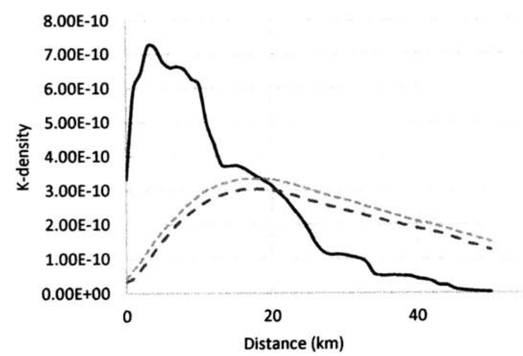


Chart5.2.21: Retails 2006 - 2015

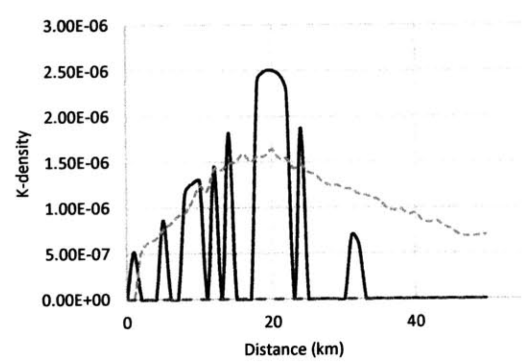


Chart5.2.22: All Retails in 2015

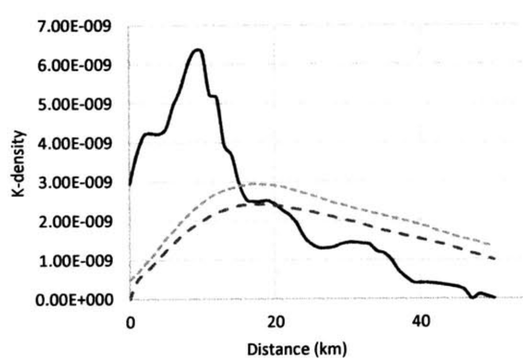


Chart5.2.23: Retails 2006 - 2015

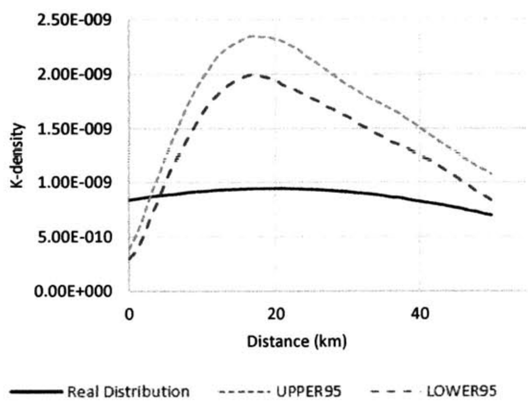
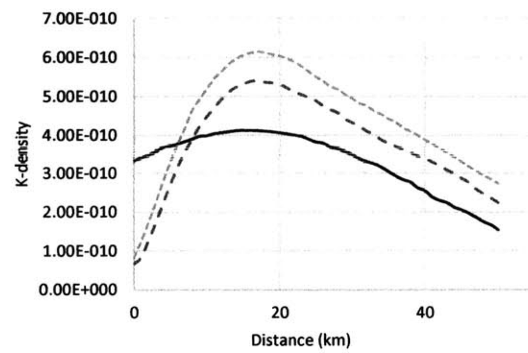


Chart5.2.24: All Retails in 2015



Guangzhou

For offices in Guangzhou, the degree of localization are highly skewed for all periods. Although the density at each distance decrease with the increase of the number of buildings, we cannot observe clear dispersed trend from the charts.

The retails patterns are quite similar to offices, which also present very pointed curves in all the four charts, although they are a little flatter than offices. The clustering of retails in Shenzhen are both strong for offices and retails, we can conclude that buildings in this city are still focused at the city center, which can also be observed in Chapter 4, Charts4.4.1-Charts 4.4.16. According to the polycentric city's theory, we can also predict that with the expansion of the city, the employment will become more dispersed in the future, then leading to a more dispersed pattern for both offices and retails.

Table 5.2.4: The buildings localization and the counterfactual

		Before 1995	1996 – 2005	2006 – 2015	Total in 2015
Offices	Localization area	[0,6 km]	[0,14 km]	[0,34km]	[0,18 km]
	Peak distance	3 km	3 km	9km	4km
	Peak value	1.71E-8	5.52E-9	4.6E-9	7.2E-10
Retails	Localization area	[0,26 km]	[0,15 km]	[0,36 km]	[0,36 km]
	Peak distance	20 km	10km	15km	15km
	Peak value	2.5E-6	6.32E-9	1.45E-10	8.17E-11

Chart 5.2.25:Offices Before 1995

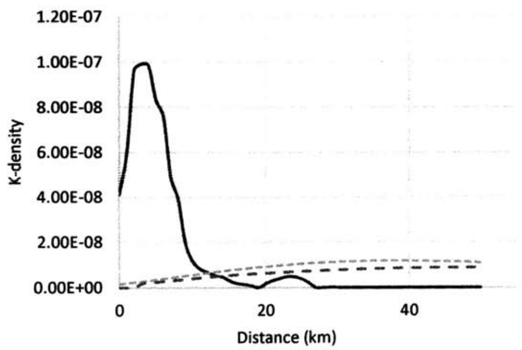


Chart 5.2.26: Offices Between 1996 and 2005

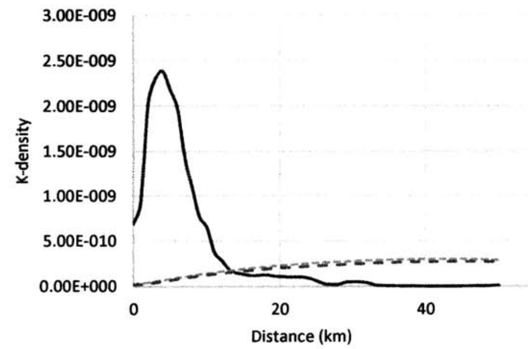


Chart 5.2.27: Offices Between 2006 and 2015

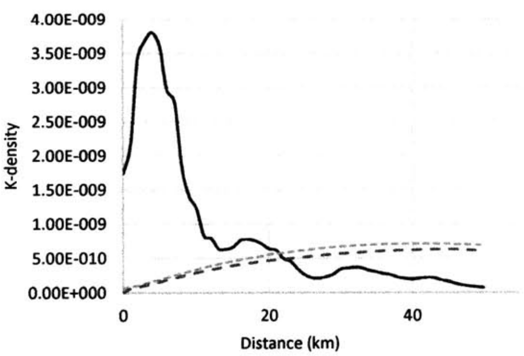


Chart 5.2.28: All Offices in 2015

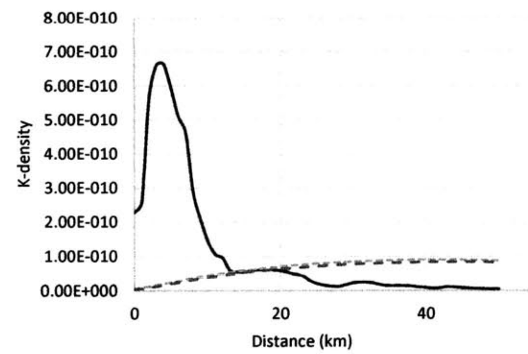


Chart5.2.29: Retails 2006 - 2015

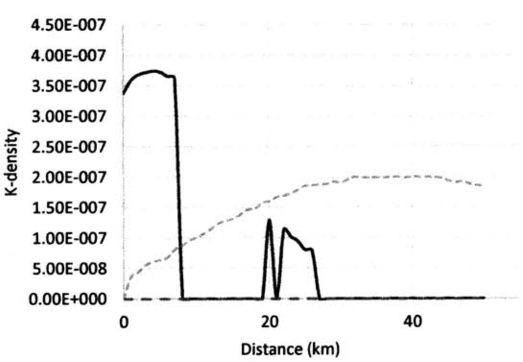


Chart5.2.30: All Retails in 2015

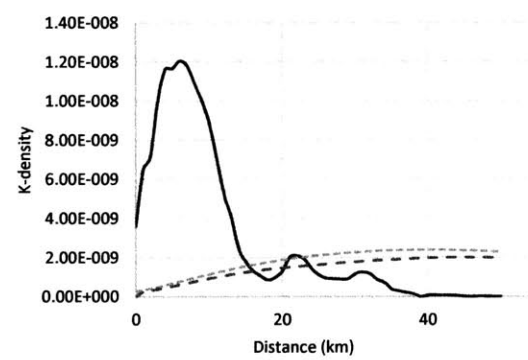


Chart5.2.31: Retails 2006 - 2015

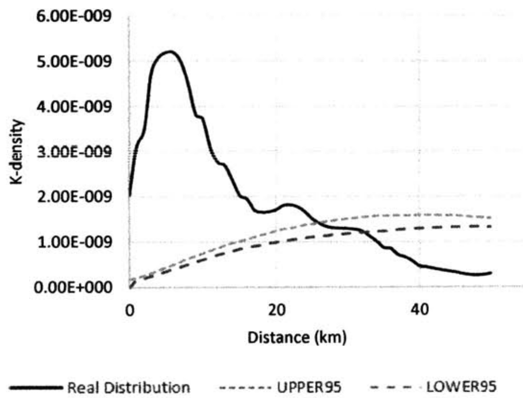
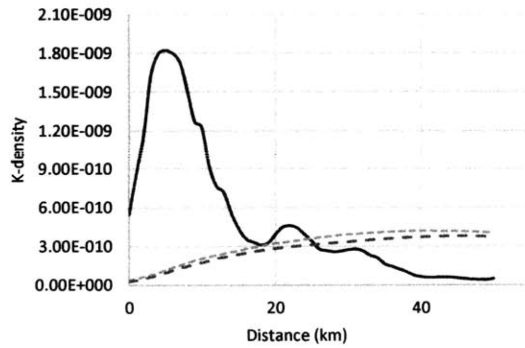


Chart5.2.32: All Retails in 2015



5.3 Co-Localization Test

For comparing the differences between the three periods, I used the K-density co-localization test, which is also raised by Duranton & Overman, initially for measuring the clustering of industries which are not independent. This method allows us to test whether buildings in one period tend to locate closer to buildings in another period than randomness would suggest.

The calculation of k-density and the set of counterfactual are generally similar to the localization test, which is discussed in Chapter 3.

There are no marked differences between the co-localization of offices in different city, whereas the retails tend to exhibit different patterns. These results are fully consistent with the facts that offices seem to cluster at fairly low spatial scales, whereas retails would locate closer to the local customers than the existing retails, so that the spatial pattern would be different among the four cities according to the distribution of residences and the traffic systems.

Shanghai

In Shanghai, Comparing the Before 95 and 1996-2005 periods, both types of buildings co-localized at small scales ([0,16km] and [0, 20 km]), while comparing the before 1995 and 2006-2015 periods, the co-localization happened at a fairly larger spatial scales ([0,22 km] and [0, 37 km]). Moreover, the shape of retail curve for Before 95 vs 2006-2015 becomes much flatter than pervious. The explanation is that at the early stages, with low expansion of residences and immature traffic system, new buildings of both type of products tend to locate proximity to existed buildings, so the CBD formed. With the expansion of city and other economic factors (such as the transportation and internet), offices and retails both tend to locate at farther distances from the traditional city center, especially the retails, which care more about the local customers.

Chart 5.3.1: Offices Before 95 vs 1996-2005

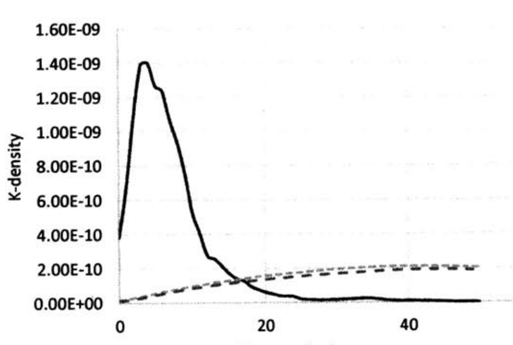


Chart 5.3.2: Offices Before 95 vs 2006-2015

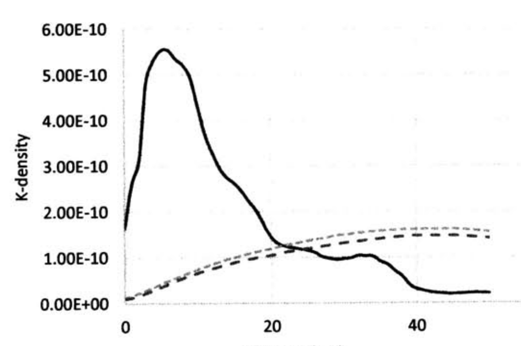


Chart 5.3.3: Retails Before 95 vs 1996-2005

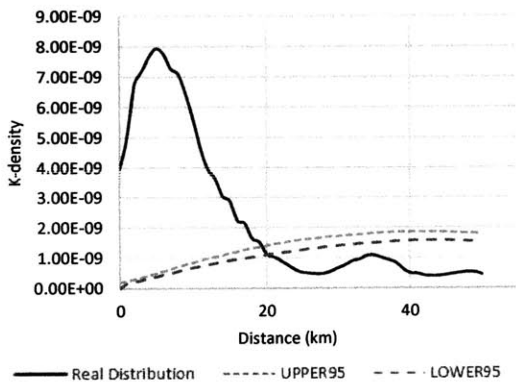
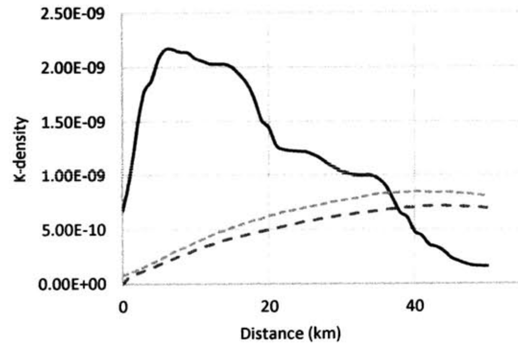


Chart 5.3.4: Retails Before 95 vs 2006-2015



Beijing

In Beijing, Comparing the before 95 and 1996-2005 periods, similar to Shanghai, both types of buildings co-localized at comparatively small scales ([0,20km] and [0, 25 km]), while comparing the before 95 and 2006-2015 periods, the co-localization happened at larger spatial scales ([0,24 km] and [0, 27 km]). We should notice that the co-localization curves of both types of buildings are quite similar in Beijing. One explanation is that, compared with Shanghai and Shenzhen, as we discussed before, Beijing is at an earlier stage of city expansion. Such as the curves of Shanghai and Shenzhen retails before 2005, they are not very dispersed as well. Another explanation might be related with the in transportation cost, which is much higher in Beijing than other cities due to the bad traffic.

Chart 5.3.5: Offices Before 95 vs 1996-2005

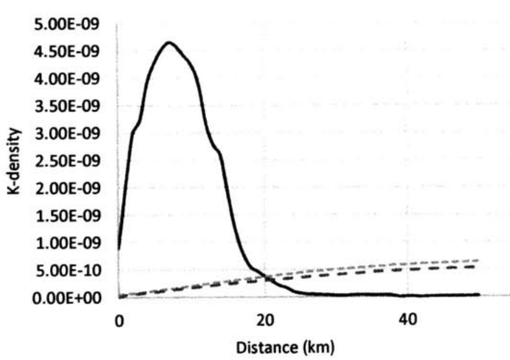


Chart 5.3.6: Offices Before 95 vs 2006-2015

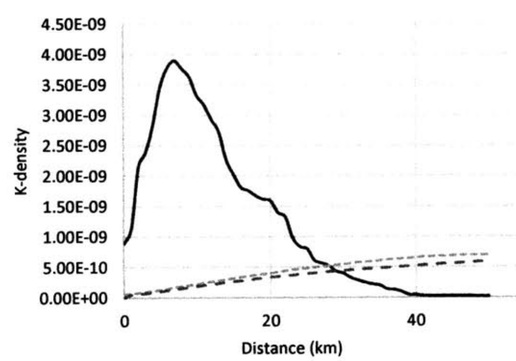


Chart 5.3.7: Retails Before 95 vs 1996-2005

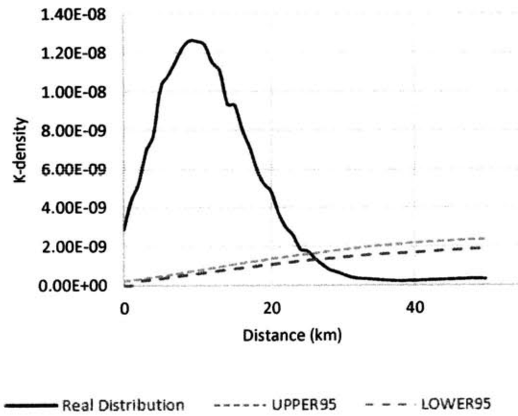
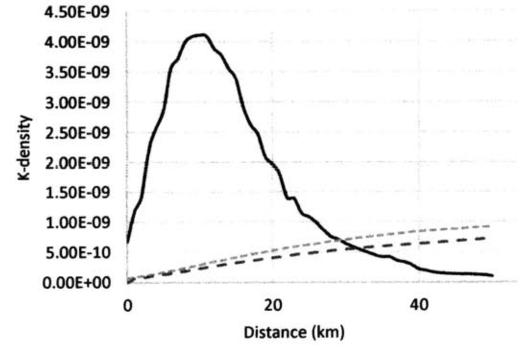


Chart 5.3.8: Retails Before 95 vs 2006-2015



Shenzhen

For the offices, we can find that the co-localization spatial did not increase as Shanghai and Beijing. The explanation might be related with Shenzhen's geography, the long coast line provide both the convenient transportation to overseas and good connection with Hong Kong , leading to increasingly more offices locate there. So that we do not observe much dispersion for offices in Shenzhen.

For the retails, however, they cannot just all cluster along the coast, the trend of following the residences making the retails' curves changed a lot. Initially a complex pattern with two peaks, co-localization peaks at 10 km and 20 km separately, which can be explained by the newly built retails both along the coast and near the residences. After that, a flat curve for retails built in before 95 vs 2006-2015 shows the dispersion trend that large portion of retails are built far from the traditional CBD, very dispersed.

Chart 5.3.9: Offices Before 95 vs 1996-2005

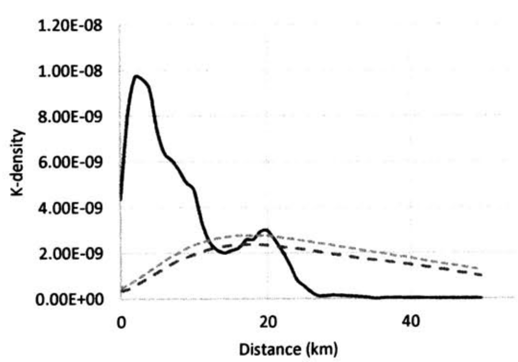


Chart 5.3.10: Offices Before 95 vs 2006-2015

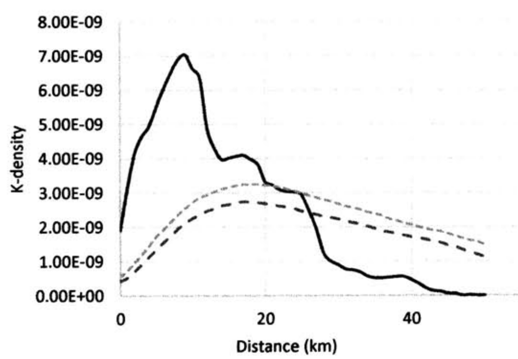


Chart 5.3.11: Retails Before 95 vs 1996-2005

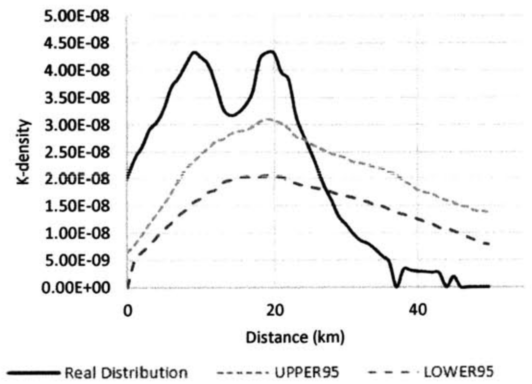
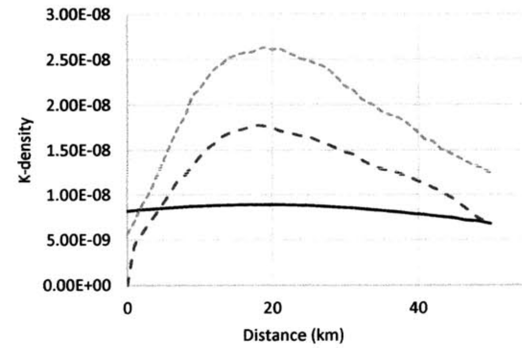


Chart 5.3.12: Retails Before 95 vs 2006-2015



Guangzhou

Guangzhou, although is one of the four 1-tier cities in China, the economy is not as developed as other three cities. We can find that the co-localization curves for both types of buildings looks very similar, all of which are very pointed, although the co-localization spatial scale also increased with time.

Chart 5.3.13: Offices Before 95 vs 1996-2005

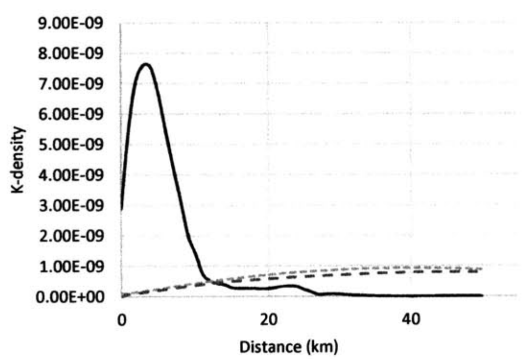


Chart 5.3.14: Offices Before 95 vs 2006-2015

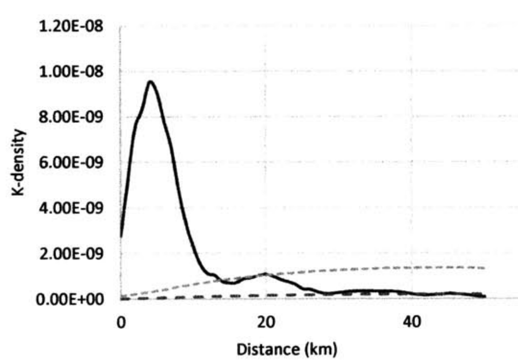


Chart 5.3.15: Retails Before 95 vs 1996-2005

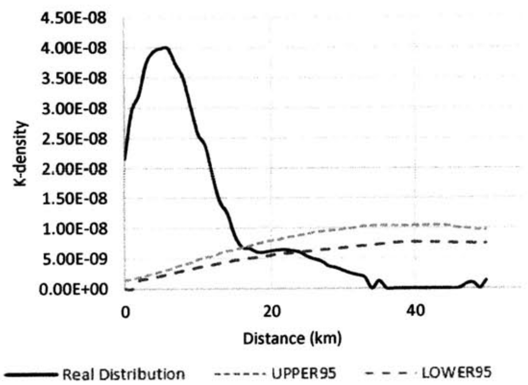
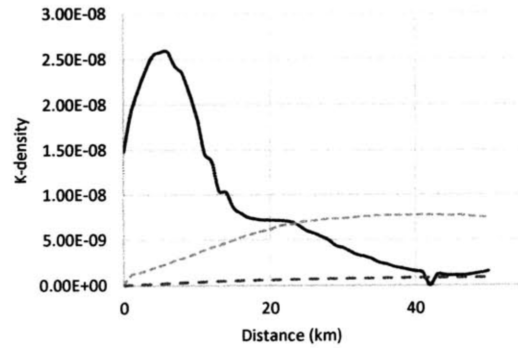


Chart 5.3.16: Retails Before 95 vs 2006-2015



Chapter 6 Conclusion

6.1 Conclusion

This paper focuses on a descriptive task that would provide some initial direction on which theories apply to the real estate distribution in several major cities in China. I mainly look at the measures of localization and co-localization within and between cities, and the changes in different time periods.

My analysis gives generally similar results across four major cities in China (Shanghai, Beijing, Shenzhen, and Guangzhou): Offices in those four cities are highly localized, while retails seem to locate in a pattern more dispersal, which well matches the theories of retail location choices. The retail location theory raised by Dudey (1990) are : two forces will influence the location choices of retails, a push cluster in order to increase demand, and a push to disperse in order to gain market power over local consumers by reducing the transportation costs.

Looking across cities, for offices, Beijing and Shanghai are similar, whereas Shenzhen and Guangzhou are generally similar. For retails, Shanghai and Shenzhen are more dispersed, whereas Beijing and Shenzhen present very strong localization and co-localization test results.

Overall, offices in all the four cities are generally localized, which suggests the existence of localization economies for offices. As most tenants of offices do not directly serve end customers, localization for them is easy to understand. However, from chapter 4, we can find that with the expansion of cities, all four cities seem growing from monocentric cities to polycentric cities, especially after 2005. There appear more and more CBDs, and the dispersion of offices appears as well, both of the phenomena well match the localization theories we discusses in chapter 2: "the dispersal of employment can greatly reduce commuting costs and residential land rents, thus accommodates urban grows to little or no increase in commuting cost."

Shanghai and Shenzhen both present flat retail K-density curves with the increase of distances, whereas Beijing and Guangzhou have highly localized retails. Strong localization would suggest that reducing transportation cost is not a driving force for retails to choose locations in Beijing and Guangzhou, they mainly focus on pursuing market power by locating proximity to other shops. Another explanation might be there is not a good transportation system for customers to travel from suburban to suburban areas. But following the trend that is commonly observed in other three cities, since the transportation would be improved for the development of city, and the demand for retails in Beijing and Guangzhou are not significantly different from other cities, as the city expands we can make a prediction that, Beijing and Guangzhou's retails would gradually present a dispersal pattern in the future.

Since our data covers four time periods, we know that the dispersed buildings in those cities are not history buildings which randomly distributed in the past, but were mainly built after year 2006, which present some evidence that the agglomeration economies may not be as importance for companies as in the old days (mainly before 2006), although it still exists.

There are some improvements that can improve this analysis. One is for the computation, as Ellison also mentioned in his thesis paper in 2010, the task of forming counterfactuals and calculating K-densities is extremely time-consuming. In the future, if the computation technology improved, we can make this analysis in greater depth. Another thing is it would also be interesting to perform the analyses on population distribution, although from the maps we can guess the dispersal of retails are following the residences, if we have the population distribution data, we can further confirm that. Moreover, using population distribution and offices distribution as new counterfactuals, we can form a test of whether retail's location distribution is affected by the agglomerative forces or local customers' forces.

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