# How Does "Xuequ" Affect Housing Prices in Central Beijing?

Website: http://dev.spatialdatacapture.org/~ucfnjwa/

## 1. Introduction

The housing prices in China have increased rapidly in recent years, particularly in Beijing. Though the government has launched relevant policies on controlling the crazy growth of housing price to deflate the real estate bubble, there still exists skyrocketing high prices of the houses, called 'Xuequfang' in Chinese, which are near top primary schools and middle schools (Hong, 2017). A more extreme example is that 11 square meters of the house in Wenchang Hutong in downtown Beijing which is near the best primary school—Beijing No.2 Experimental Primary School, was sold by 460000 yuan (equal to about 73000 dollars) per square meters (Xinhua, 2016). Though the prices of the houses, located in coveted school-districts in which top primary schools and middle schools are concentrated, might be too high to afford, many parents are still eager to buy them in order to get better education for their children. There is still a huge demand of school-district houses in the real estate market in Beijing (Wen, Zhang, and Zhang, 2017).

In China, the 'nearby enrollment' policy which means that schools to admit children who live locally, especially those whose 'Houkou' is in the area and whose family own a property nearby, is the basic admission policy of public schools in the compulsory education system (Li and Blanchard, 2013), and the scale of the school-district is based on this policy. Good school-districts will offer a great deal benefits to the neighborhood residences (Bogart & Cromwell, 1997). As a result, if the residents live in a good district which are located with top primary and middle schools, their children have strong opportunities to go to these schools. Chinese families put enormous emphasis on education and they are willing to change the locations of houses for better education. Many parents believe that choosing a right primary school for their children is essential for them to have good high school education followed by a prestigious university (Li and Blanchard, 2013). In addition, the imbalance distribution of good educational resources increases people's desire for better resources. Therefore, the 'school-district houses' become more popular in the real estate market.

Some researches has indicated that school facilities have positive effects on housing prices (Wen, Zhang, and Zhang, 2014). This research aims to choose Beijing, the most obvious phenomena of school-district houses in China, as the research objective to explore whether school-districts (called 'Xuequ' in Chinese) affect housing prices and if affect, how do they affect and which elements significantly affect. Four administrative districts are selected in this research, Xicheng, Dongcheng, Haidian and Chaoyang, in which top primary schools and middle schools are mainly distributed. This study will figure out the relationship between school-districts and housing price in the entire selected areas and each district. Based on the 'nearby enrollment' policy, each administrative district has different educational policies on enrollment of primary schools or middle schools, which might cause varying degrees of impact.

The structure of the report is as follows. The following section explains the detailed enrollment policies in Beijing. Next, it introduces the existing researches on school-district houses. Some thoughts of data visualization are stated in the third part and then the report explains the process of data mining and data processing. This is followed by methodology on which method is applied to analyze the research question. Subsequently, it comes concluding remarks, and limitation and future extension are contained in the end.

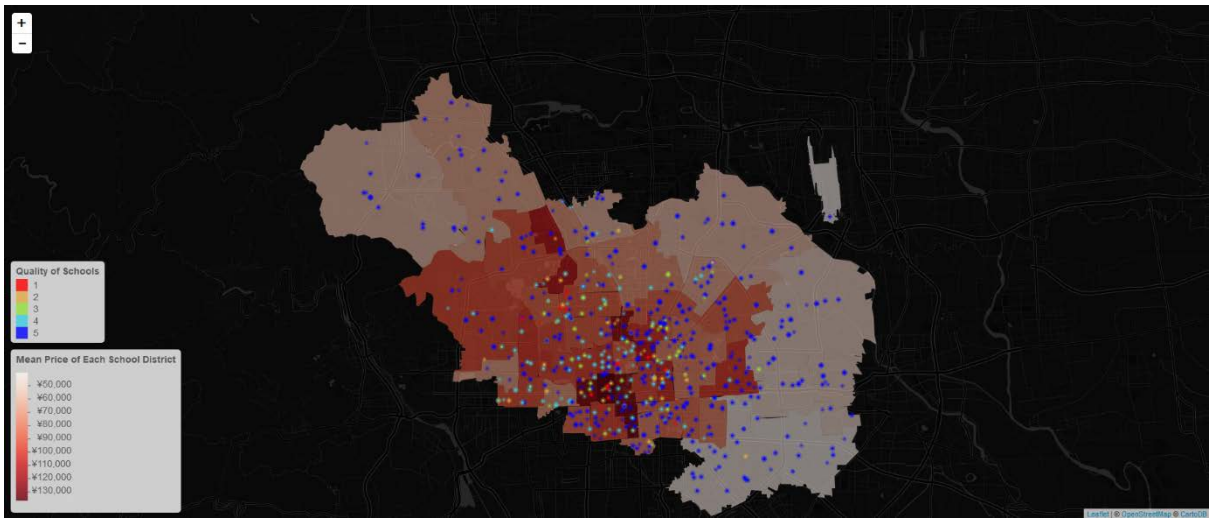


**Figure 1** Housing prices in the center of Beijing are the most expensive. And most of the educational resources are clustered here.

## 2. Explanation of Enrolment Policies

Here are the explanations of some official nouns in the enrolment policies and detailed enrolment policies in each administrative districts (Xiaoshengchu, 2017). **Table 1** shows some of the definitions.

| Terms | Definitions |
|---|---|
| School-districts | The area regulated by Administrative District Educational Committee includes public primary and middle schools. |
| Nine-year Compulsory Education | All citizens must attend school for at least nine years, known as the nine-year compulsory education, which are funded by the government, including primary and middle school education. |
| School Quality | Evaluation on the schools' infrastructure, teaching resources and level of examination results; the levels of school qualities include Class 1 Division 1, Class 1 Division 2, Class 2 Division 1, Class 2 Division 2 and General |
| Corresponding Middle School | According to annual policy from Education Bureau, some of primary school could directly transit to this middle school. |
| Nine-year Education School | The school which contains primary and middle schools; all students could directly get to the middle school section |
| Direct-transition | The proportion of students who graduate from the primary school could transit to corresponding middle school without examination |
| Random Designation | The Education Committee carries out computer assignments by default. The selection prefers to the option of the closest school. If the quota of the closest school is full, the result changes to another school. |

**Table 1** Definition of Terms

The enrolment policies of primary schools are different in these four areas. In Xicheng, Dongcheng and Haidian, children who are eligible for primary school enrolment could be enrolled in the school whose enrolment range contains their residence area. While in Chaoyang district, each residence is not absolutely corresponded to only one primary school. For those whose location are corresponded to more than one schools, children are obliged to

participate in the ‘random designation’ process, in which they are randomly distributed to the primary schools which their residences are correspond to.

For the enrolment policies of middle schools, in these four districts, if students are from primary schools with promotion pathways, a specific proportion of them will be enrolled in the corresponding middle school. Otherwise, the situations are different in these four areas. In Xicheng district, students could choose to be enrolled into schools eligible for ‘registration enrolment’, or randomly designated into schools within the school-district or even the whole Xicheng district. In Dongcheng district, students could take part in “random designation” procedure, which is divided into three stages. First, every student is allowed to take part in the “registration enrolment” process. If they withdraw such chance, they could choose at most eight middle schools within Dongcheng district which they are most interested in. Students who are not enrolled in any of their eight interested middle schools will take part in the third stage, in which they are to be randomly designated to middle schools within the same school-district as the primary school. In Haidian, students have several ways to be enrolled in middle schools. They could choose registration enrolment, in which students could choose no more than three candidate middles schools within the enrolment district (a specific kind of district regulated by Haidian district) their primary schools belong to. Students would be randomly designated to one of their candidate schools. Furthermore, students also could choose to be randomly designated into one of the middle schools within the school-district the primary school belongs to. Finally, in Chaoyang, students could choose to be enrolled into a general middle school, which is eligible for registration enrolment and close to their households. If their households are located in the enrolment range of either one or more than one middle schools, they could choose to be enrolled in one of those middle schools. If the number of application of one middle school exceeds its quota, students applying for it would be randomly designated into other middle schools whose enrolment ranges contain their households.

## 3. Literature Review

The relationship between public resources and housing prices has always been a widely concerned issue. Tiebout (1956) has concluded that people will move to their preferred residential location according to their income, and the public resources around the residence, which will finally lead to the capitalization of the benefit of these public resources into housing prices of surrounding areas. Such theory was adopted as the basis for research on relationship between housing prices and different kinds of public goods such as green space, metro stations and schools, etc. Since Oates (1969) who revealed the strong correlation between expenditure of government in schools and housing prices in New York, in western countries many research about relationship between educational resources and housing prices has been conducted by hedonic price model, which was improved and widely used in real estate market studies (Wen, Xiao and Zhang, 2017).

However, research of the capitalization of educational resources into housing prices were not paid much attention to in China. Some of the studies might be involved with the school factors when effects of other public goods on housing prices were being considered. For example, Zheng and Kahn (2008) found that housing prices could be increased by shorter distance to high-quality schools when they were exploring determinants of housing prices in Beijing. Only a few studies focused on this topic and concluded that educational resources could positively affect housing prices. (Wen, Xiao and Zhang, 2017) Among these studies, Wen, Xiao and Zhang (2017) and Feng and Lu (2013) are the two representatives. The former one focuses on how quality of primary and middle schools affect housing prices in Hangzhou by spatial econometrics models, and the latter one focuses on the factors of senior

high schools density by traditional hedonic price model. However, comprehensive consideration of school factors are still lacked in these two studies. Other possible factors such as high quality schools within the school-district the house is located in are not considered.
Thus, this report will attempt to contain more school factors to have a deeper understanding of the capitalization effects of educational resources, based on the case of Beijing.

## 4. Website Design

The website, as the presentation of this research, includes two major sections, storytelling and data visualization.

The storytelling generally introduces the phenomena of school-district house, relevant enrollment policies in each district and the distribution of housing price and high quality schools. It illustrates the correlation between schools and housing price with several dynamic graphs. They are divided into three sections to show the relationship between housing price and school factors, which are school density, primary school factors and middle school factors. Selection boxes are offered for users to choose their interested elements, figuring out the correlation with housing price.

The data visualization on this website is to present the spatial distribution of school data and housing data, further exploring the connection between schools and the housing price. Three types of selections are listed in the left of the website. Users could choose 'School Selection', 'Housing Section' and 'School-district' to get the information they want. The event for 'School Selection' is for users to filter the primary schools and middle schools with different level of qualities in each district, and the scale of each school-districts. 'Housing Selection' helps users to choose what kind of housing they intend to find, including the building age, the housing price they could afford, etc. Detailed school information and housing information could be found in the pop-up window. Besides, the event for 'School-district' shows the choropleth maps on the density information of primary schools and middle schools in each school-district, more intuitively to observe the school information.

Additionally, the introduction of website constructors and links to downloads of the data which are used in this study are designed on the 'about us' webpage.

## 5. Data Management

### 5.1 Data Scale

The object of this research is the relationship between the schools and the housing price in Beijing. First, it is necessary to define the spatial and temporal scale of the housing price data and school data. All data and documents were collected during a week from 15th to 22nd in April 2018, which means that the information only matches the updated situations before April 15, 2018. The spatial scale of this study are explored in the four main administrative districts, Xicheng, Dongcheng, Haidian, and Chaoyang. The reason is that most of housing trades are distributed in these four districts and the schools in these areas influence the housing price more significantly than other districts in Beijing. In addition, housing price data only includes second-hand housing since property transactions in these four areas are mostly second-hand housing transactions rather than new housing. Besides, there is a policy of compulsory education in China so that the location of primary schools and middle schools can influence housing market significantly. Therefore, only primary and middle schools in the four districts are taken account for in the research.

### 5.2 Data Mining

There are three types of data -- housing price, infrastructure information, school information and their location data. The housing price data were collected from Chinese biggest property trade website -- Lianjia (The detailed website address are given in the appendix: data source). the data contains the information of housing price, age, and other attributes. The school data is collected from the Chinese Education website. Policies about schools and their school-districts are collected from the Beijing Xiaoshengchu website and the Beijing Municipal Education Commission website. In addition, according to the documents given by the Beijing Municipal Education Commission, the boundaries of school-districts are drawn manually by using ArcGIS, and the corresponding relationship between primary schools and high schools are input manually as well.

### 5.3 Data Cleaning and Manipulation.

Data cleaning involves three aspects. First, it is to deal with data's null value, especially for the housing price data. Many attributes have not been given in the second-hand housing transaction items. In addition to the elevator information, all data items with null values have been deleted. As for the elevator information, the second-hand houses with null value are all old buildings. According to the building story and conditions in China, they are automatically set as houses without the elevator. Secondly, the text information in the data was converted into specific variables. Third, the data from different sources are linked together by key values and corresponding relationships to form a neat data table. The data table also needs the following steps: First, the spatial information is obtained. The Baidu Map API was used to convert the text information into spatial coordinates. Second, the spatial coordinate projection system is adjusted, Baidu Map API returns geolocation containing its dedicated BD01 coordinate system that needs to be converted to WGS84. In addition, as Google projects by the Mars coordinate system inside Chinese territory, the WGS84 geolocation also needs to be converted to the Mars coordinate system. In addition, the algorithm converts the WGS84 to the Mars coordinate system would output a few inaccurate coordinates, this output was regulated manually by ArcGIS.

### 5.4 Data Storage and Flow

This site is a database-based project. Data is processed in Python and then stored in the MySQL database. Data on the SQL interact with JavaScript programs through APIs. At the same time, the database-based workflow will help the website to be updated in real time as a future work extension. Shapefiles which are not supported for MySQL are converted to geojson and stored on the server for JavaScript calls. The dynamic graphs drawn by the Highchart use the data in the form of JSON product by Python and the JavaScript files were also uploaded to the server. When the data need to be uploaded, the datasets on the SQL are connected by Python and the data can be manipulated interactively with MySQL.

## 6. Methodology

### 6.1 Hedonic Price Model

Hedonic price model is the most common housing price evaluation method in previous research. (Xiao and Webster, 2017) Dependent on the linear regression, it enables the identification of how different factors affect housing prices (Henneberry, 1998).

According to previous research, after several trials, the logarithmic form of hedonic price model is adopted (Wen, Xiao and Zhang, 2017).

$$\ln P = b_0 + \sum_i b_i x_i + e_i$$

Where P is the price of a house, $b_i$ are the coefficients of the predictors $x_i$ and $e_i$ is the residual.

This model assumes that no correlated error terms exist and all the factors are independent from spatial variations (Osland, 2010).

### 6.2 Factors

In previous research, factors for housing price studies include these categories: property variables, neighborhood variables and location variables (Dai, Bai and Xu, 2016).

As the focus of this study is the effects of schools on housing prices, school factors become another part of variables. According to Feng and Lu (2013), the density of schools around a house would also affect the housing price. Thus, school factors could be divided into three parts: school density, primary school factors and middle school factors.

School density is defined as the number of schools per square kilometer within the radius of 1.5 km from the house. This study will take into account of density of both non-general primary schools and non-general middle schools.

The enrolment in primary schools in all four administrative districts obey the "nearby enrolment" policies. This indicates the primary school whose enrolment range contains the house will affect its housing price. In this study, the closest primary school from this house is assumed to be the primary school which will accept the children of this household, due to the unavailable information of the enrolment range of each primary schools.

Besides, as some of the primary schools have direct transition approach to corresponding middle schools, these corresponding middle schools might also have effect on prices of houses within the enrolment range of these primary schools.

As for middle schools, according to the aforementioned introduction of middle school enrolling policies, there are three kinds of middle schools that might make a difference on housing prices: highest quality of middle schools within the school-district, highest quality of middle schools within the administrative district, and the middle school nearest to the household.

**Table 1** summarizes all the predictors and **Table 2** lists the value of some of the variables.

| Characteristic Categories | | Variables | N | Min. | Max. | Mean | S.D. | Expected Effects |
|---|---|---|---|---|---|---|---|---|
| **School factors** | **School categories** | | | | | | | |
| | Closest primary schools to the house | Quality | 2230 | 1 | 5 | 4.18 | 1.09 | - |
| | | Distance to it | 2230 | 0 | 4094.2 | 567.40 | 428.52 | - |
| | | Have Transition approach or not | 2230 | 0 | 1 | 0.33 | 0.47 | + |
| | Corresponding middle school of the nearest primary school to the house | Quality | 727 | 1 | 5 | 4.44 | 1.02 | - |
| | | Distance to it | 727 | 0.42 | 12498.63 | 1179.71 | 1458.69 | - |
| | | Transition rate from | 727 | 0.2 | 1 | 0.81 | 0.28 | + |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | the primary school to it | | | | | | |
| | Best middle school within the school-district of the house | Quality | 2230 | 1 | 5 | 3.67 | 1.41 | - |
| | | Distance to it | 2230 | 0 | 18935.20 | 1730.80 | 2919.17 | - |
| | Best middle school within the administrative district of the house | Quality | 2230 | 1 | 2 | 1.51 | 0.50 | - |
| | | Distance to it | 2230 | 103.80 | 22641.3 | 4055.10 | 2718.61 | - |
| | Closest middle schools to the house | Quality | 2230 | 1 | 5 | 4.71 | 0.77 | - |
| | | Distance to it | 2230 | 0 | 5406.80 | 708.60 | 496.69 | - |
| | | Density of non-general primary schools | 2230 | 0 | 1.65 | 0.48 | 0.45 | + |
| | | Density of non-general middle schools | 2230 | 0 | 1.00 | 0.09 | 0.15 | + |
| **Property factors** | | Having lift or not | 2230 | 0 | 1 | 0.54 | 0.50 | + |
| | | Building age | 2230 | 3 | 68 | 22.30 | 10.31 | - |
| **Neighbourhood factors** | **Facility categories** | | | | | | | |
| | Green spaces within the radius of 1.5km from the house | Number of these green spaces | 2230 | 0 | 11 | 2.15 | 2.01 | + |
| | Closest green space to the house | Category | 2230 | 0 | 1 | 0.98 | 0.15 | / |
| | | Distance to it | 2230 | 0 | 8834.50 | 1119.50 | 739.60 | - |
| | Metro stations within the radius of 1.5km from the house | Number of these metros | 2230 | 0 | 10 | 2.76 | 1.83 | + |
| | Closest metro station to the house | Distance to it | 2230 | 0 | 4048.10 | 864.20 | 545.96 | - |
| | Closest hospital of level 2 | Distance to it | 2230 | 0.42 | 8405.50 | 1761.20 | 1389.54 | - |
| | Closest hospital of level 3 | Distance to it | 2230 | 55.98 | 9397.94 | 2010.91 | 1471.09 | - |
| **Location factors** | | Distance to Tiananmen Square | 2230 | 595.4 | 32238.30 | 7781.80 | 4060.87 | - |

**Table 2** Summary of Predictors

| Variables | Value | Meaning |
|---|---|---|
| **Quality of Schools** | 1 | Class 1 Division 1 schools |
| | 2 | Class 1 Division 1 schools |
| | 3 | Class 1 Division 1 schools |
| | 4 | Class 1 Division 1 schools |
| | 5 | General schools |
| **Have transition approach or not** | 0 | The primary school does not have any transition approach to other middle schools |
| | 1 | The primary school has transition approach to other middle schools |

| | | |
|---|---|---|
| **Having lift or not** | 0 | No lift |
| | 1 | Have lift |
| **Category of green space** | 0 | Country park |
| | 1 | Registered park |

**Table 3** Values of Some of the Variables

### 6.3 Moran's I

As there might be interdependence of housing prices among observations in neighbouring areas, spatial autocorrelation might exist in housing prices (Osland, 2010). Thus, Moran's I will be conducted to test for these spatial effects.

$$I = \frac{N}{\sum_i \sum_j w_{ij}} \cdot \frac{\sum_i \sum_j w_{ij}(X_i - \bar{X})(X_j - \bar{X})}{\sum_i (X_i - \bar{X})^2}$$

In the formula, N is the number of observations. $X_i$ and $X_j$ are the variables of interests of observation i and j. $\bar{X}$ is the mean value of all the observations, and $w_{ij}$ is the spatial weight between i and j. When I is being closer to 1, the value of observations will show a clustered pattern. If it is close to 0, no spatial autocorrelation exists.

As the exact locations of each house are available, and they are distributed unevenly in space, the weight matrix will be created according to k-nearest neighbours to ensure that each observation has neighbours. Since houses within the same school-district tend to be affected in a similar way, and most of the school-districts contains around 40 observations, thus k is set to 40 in this study. As for the weight style, the row standardized style is adopted, since "it is the style that is most commonly used in econometrics". At last, Moran's I will be estimated by normality approach since a large set of observation is available in this research. (Osland, 2010, p.301)

### 6.4 Spatial Econometrics Models

Because of the unavailability of data, it is not realistic to include all neighbourhood effects into the hedonic price model in most cases. Moreover, the OLS approach of hedonic price model often produces biased estimation. (Wen, Xiao and Zhang, 2017)

Spatial econometric models have a series of advantages. First, it could effectively deal with neighbourhood effects. Then, it could focus on spatial factors of housing prices and mitigate the issues of omitted variables in traditional hedonic price models. Next, goodness-of-fit of models could be improved by spatial econometric models. (Wen, Xiao and Zhang, 2017)

There are two forms of spatial econometric models, the spatial lag model (SLM) and the spatial autoregressive error model (SEM), dealing with the problem of spatial autocorrelation in the dependent variable and the residual respectively (Osland, 2010).

The spatial lag model is defined as:

$$P = \rho WP + X\beta + \varepsilon$$

| Symbol | Meaning |
|---|---|
| **P** | Housing price |
| **W** | Spatial Weight Matrix |
| **ρ** | Intensity of dependence between neighbouring prices |
| **X** | Vector of independent variables |
| **β** | Vector of regression coefficients |
| **ε** | Error terms |

**Table 4** Symbols of Spatial Lag Model

And the spatial autoregressive error model is defined as:

$$P = X\beta + \varepsilon$$
$$\varepsilon = \lambda W\varepsilon + u$$

| Symbol | Meaning |
|---|---|
| **P** | Housing price |
| **X** | Vector of independent variables |
| **β** | Vector of regression coefficients |
| **ε** | Error term |
| **λ** | Spatial autoregressive parameter to be estimated |
| **W** | Spatial Weight Matrix |
| **u** | The error term in ε |

**Table 5** Symbols of Spatial Autoregressive Error Model

### 6.5 Framework of the Study

First, the Ordinary Least Square (OLS) regression is conducted on all the predictors. Next, the Moran's I test will be performed based on the residuals of the OLS model to prove the spatial autocorrelation issue, after which the Spatial Error Model will be chosen to improve the traditional OLS approach. Then, analysis will be done for the overall four administrative districts. The relationship between housing prices and schools will also be explored in each administrative district. At last, conclusion will be given.

## 7. Result & Discussion

### 7.1 Constructing the OLS Model

The OLS regression is conducted on all predictors. Predictors with variance inflation factor (VIF) higher than 4 will be removed from the model.

Then, the OLS model keeps the factor of "having transition approach or not" and leaves out all the factors of "corresponding middle school of the closest primary school to the house" because primary schools without transition approaches do not have information of "corresponding middle schools". According to the regression results, the coefficient of "having transition approach or not" is insignificant. Then, the OLS model is conducted only on houses whose closest primary schools have transition approach. The results still show insignificant results of these factors. So, the transition approach of primary schools do not have significant effects on housing prices and their factors are removed from the OLS model.

### 7.2 Consideration of Spatial Effects

**Figure 1** shows that there is some spatial autocorrelation in the residuals of the previous OLS model. The Moran's I Test in **Table 4** shows the significant p-value (<0.05), with the Moran's I greater than 0, illustrated in the Moran's Plot in **Figure 2**. Then, the OLS model passes both the LM-lag test and the LM-error test (**Table 6**). All these tests prove the spatial autocorrelation within the residuals of the previous OLS model.

As the test statistics of SEM in both LM-tests are larger, and the AIC of SEM is the lowest among all the models (**Table 7**), SEM is chosen for the following analysis (**Table 8**).

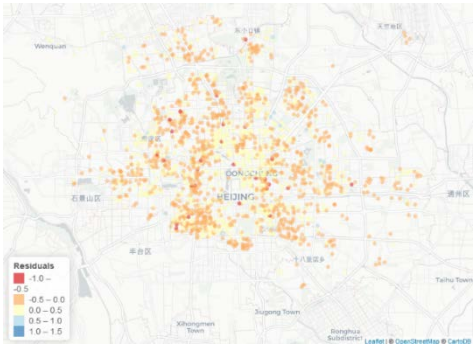


**Figure 3** Spatial Distribution of Residuals from the OLS Model

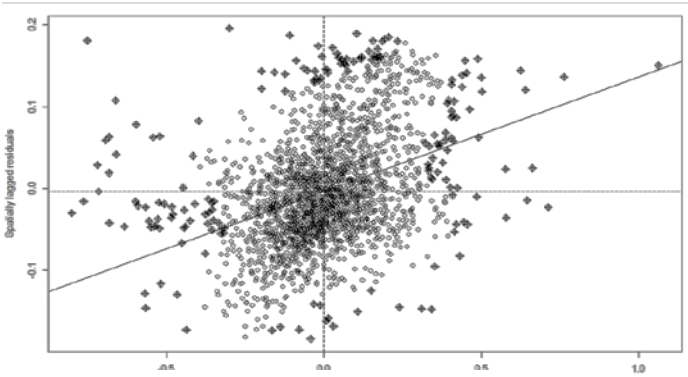


**Figure 3** Moran's Plot of the Result

| **Statistics** | **Value** |
|---|---|
| **Z-score** | 31.386 |
| **P-value** | 2.2e-16 |
| **Moran's I** | 0.140 |
| **Expectation** | -4.486e-4 |
| **Variance** | 2.001e-5 |

**Table 6** Results of the Moran's I Test

| | **LM-test** | | **Robust LM-test** | |
|---|---|---|---|---|
| | Statistics | P-value | Statistics | P-value |
| **SEM** | 958.86 | <2.2e-16 | 371.23 | <2.2e-16 |
| **SLM** | 611.68 | <2.2e-16 | 24.045 | 9.4e-7 |

**Table 7** Results of Lagrange Multiplier (LM) Tests

| | **OLS** | **SEM** | **SLM** |
|---|---|---|---|
| **AIC** | -1253.674 | -1561.491 | -1523.401 |

**Table 8** AIC of Each Models

| **Characteristic Categories** | | **Variables** | **Estimate** | **P-value** |
|---|---|---|---|---|
| **School factors** | **School categories** | | | |
| | Closest primary schools to the house | Quality | -1.17e-2* | 0.0061 |
| | | Distance to it | -1.26e-5 | 0.2636 |
| | Best middle school within the school-district of the house | Quality | -1.60e-2* | 0.0054 |
| | | Distance to it | -2.84e-7 | 0.9138 |
| | Best middle school within the administrative district of the house | Quality | -0.223* | 2.00e-15 |
| | | Distance to it | -4.38e-5* | < 2.2e-16 |
| | Closest middle schools to the house | Quality | -2.55e-3 | 0.6791 |
| | | Distance to it | -4.60e-6 | 0.6547 |
| | | Density of non-general primary schools | 6.73e-2* | 0.0002 |
| **Property factors** | | Having lift or not | -7.46e-3 | 0.3997 |
| | | Building age | -2.34e-3* | 2.300e-7 |
| **Neighbourhood** | **Facility categories** | | | |

| | | | | |
|---|---|---|---|---|
| **factors** | Closest metro station to the house | Distance to it | -1.58e-5 | 0.099 |
| | Closest hospital of level 3 | Distance to it | 1.77e-5* | 0.0078 |

**Table 9** Results of SEM
Note: "*" represents the 5% significant level.

7.2.1 School Density

According to **Table 8**, the density of non-general primary have significant effects on prices of houses within that school-district, with the instantaneous increase rate of 6.73%. As more non-general schools in the same area of space indicates that people living nearby this area have more chance to receive good education, which will raise the demand of housing here, and their housing prices.


**Figure 5** Relationship between Primary School Density of a School-district and Housing Prices


**Figure 4** Distribution of Housing Prices and the Quality of Their Closest Primary Schools

7.2.2 Primary Schools

For primary schools, the coefficient of quality of schools is significant but that of distance is not. While the quality of the closest primary school is declined to a lower level, the instantaneous decline rate of housing price is 1.17%. Then, the children of the household could be enrolled in the primary school as long as the household is within the enrolment range of the primary school, so distance to the closest primary school does not affect housing prices.

7.2.3 Middle Schools

For middle schools, quality of the best middle schools within both the school-district and the administrative district have significant effects on housing prices, with the instantaneous decline rate of 1.6% and 22.3% respectively when the quality is declined to one lower level. Neither the quality of the closest middle schools nor the distance to it has significant effects.

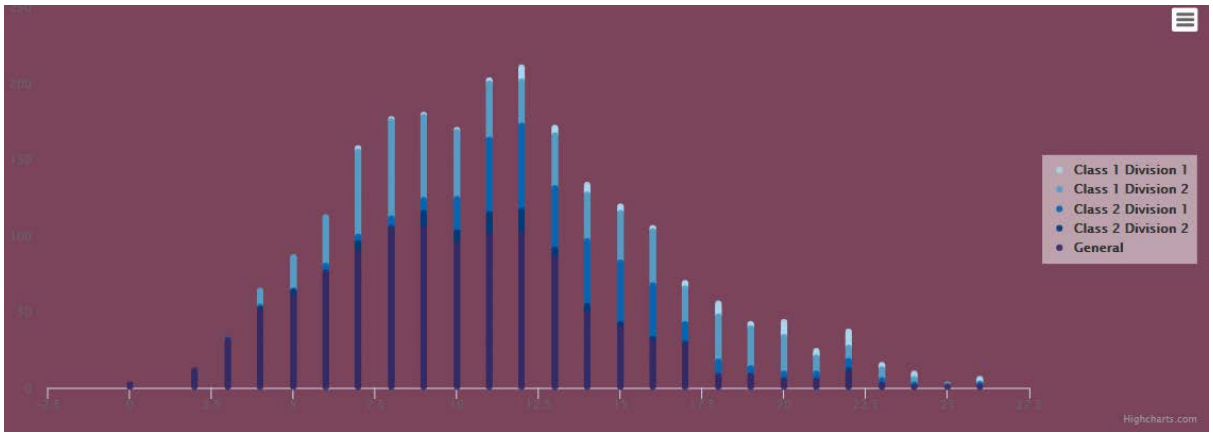


**Figure 7** Distribution of Housing Prices with the Quality of Best Middle School Within the School-district

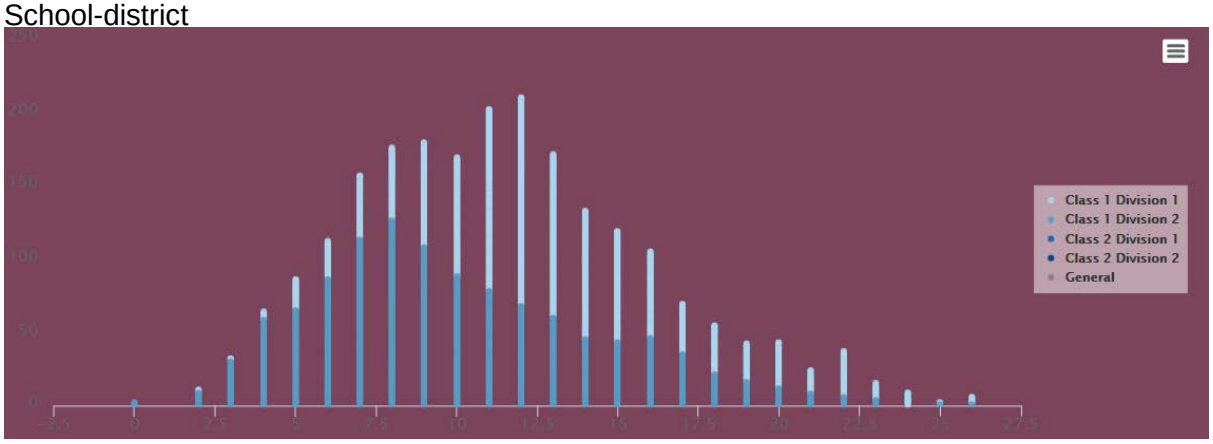


**Figure 6** Distribution of Housing Prices with the Quality of Best Middle School Within the Administrative District

(1) Best middle school within the school-district

Compared to primary schools, quality of middle schools have larger effects on housing prices, which shows that people pay more attention to good quality middle schools, because studying in a good junior high school implies a better chance to be enrolled into a good senior high school. Since the policies in four administrative districts are all involved with policies of random designation to middle school within school-districts, living in a school-district where there are middle schools of high quality indicates that there is chance for children to be enrolled in these good middle schools. Thus, houses within these school-districts will be much more popular than others, which raises the housing prices in these places.

According to the random designation policy, every household within the same school-district will have equal chance to be enrolled in the best school of the school-district. So, distance to this school has little effect on housing prices.

(2) Best school within the administrative district

Then, administrative districts whose best middle schools have higher quality imply that the overall quality of this administrative district is higher, which has more attraction to people and increases the housing price. As is shown in **Table 6**, the quality of best middle schools in Xicheng and Haidian is Class 1 Division 1, and that in Dongcheng and Chaoyang is Class 1 Division 2. Such educational advantage is further exemplified by the number of non-general middle schools in these two districts (10 and 19), compared to that in Dongcheng and Chaoyang (only 5 and 4). Thus, the agglomeration effect of the high quality schools increases the housing prices in Xicheng and Haidian.

| Administrative Districts | Xicheng | Dongcheng | Chaoyang | Haidian |
|---|---|---|---|---|
| **Number of Class 1 Division 1 Middle Schools** | 3 | 0 | 0 | 1 |
| **Number of Class 1 Division 2 Middle Schools** | 2 | 3 | 3 | 5 |
| **Number of Class 2 Division 1 Middle Schools** | 5 | 2 | 1 | 4 |
| **Number of Class 2 Division 2 Middle Schools** | 0 | 0 | 0 | 9 |
| **Number of Non-general Middle Schools** | 10 | 5 | 4 | 19 |
| **Mean Housing Prices (Yuan per square meters)** | 105165 | 96620 | 71089 | 86002 |

**Table 10** Summary of Non-general Middle Schools in All Four Administrative Districts

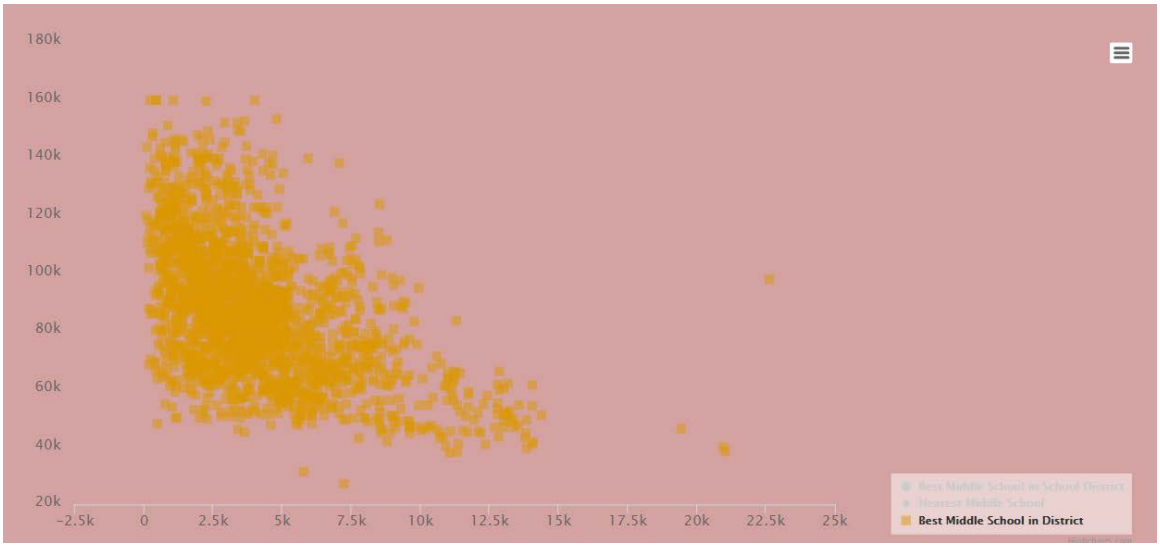


**Figure 8** Correlation between Housing Prices and Distance to the Best Middle School in the Administrative District

Distance to the best middle school in the administrative district has significant effect on housing prices. One of the possible reasons is that children living very close to such schools

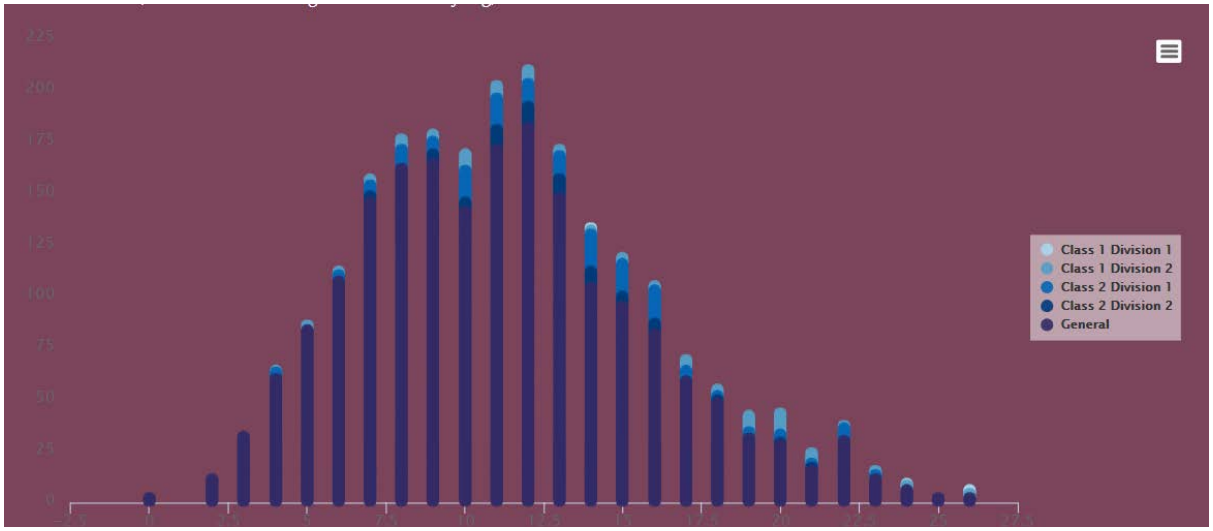


**Figure 9** Distribution of Housing Prices with the Quality of the Closest Middle School

still have chances to be enrolled because some of the administrative districts have random designation policies applied to the neighbouring school-districts or even the whole administrative district. Other reasons will be further discussed for each administrative district in the following paragraphs.

(3) Closest middle school

Except Chaoyang, none of the other administrative districts has school enrolment policies involved with nearby enrolment, and the closest middle school to the household does not have significant effects on housing prices in these administrative districts, including Chaoyang.

### 7.3 Comparison of the Effects Among Four Administrative Districts

The SEM model is constructed for each of the four administrative districts to compare the effects of different school enrolment policies. As the quality of the best middle school within the same administrative district is the same for all the houses located within it, the predictor "quality of the best middle school within the administrative district" is removed in these models. Results are shown in **Table 10**.

| **Characteristic Categories** | | **Variables** | **Estimates of Each Administrative District** | | | |
|---|---|---|---|---|---|---|
| | | | Xicheng | Dongcheng | Chaoyang | Haidian |
| **School factors** | **School categories** | | | | | |
| | Closest primary schools to the house | Quality | -1.02e-2 | -7.74e-3 | -1.42e-2 | -8.02e-3 |
| | | Distance to it | -4.22e-5 | 5.72e-5 | -3.14e-5 | -1.79e-5 |
| | Best middle school within the school-district of the house | Quality | -2.75e-2* | -2.02e-2 | 2.71e-2 | 9.78e-3 |
| | | Distance to it | -4.94e-5 | 5.07e-6 | 6.63e-6* | 3.29e-5* |
| | Best middle school within the administrative district of the house | Distance to it | -5.63e-5 | -6.56e-5* | -5.61e-5* | -3.51e-5* |
| | Closest middle schools to the house | Quality | -8.95e-3 | -1.62e-2 | 3.00e-3 | 8.98e-5 |
| | | Distance to it | -5.81e-5 | -7.51e-5* | -2.37e-5 | -3.06e-6 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Density of non-general primary schools | -6.02e-3 | 8.56e-3 | 1.19e-1 | 7.37e-2 |
| **Property factors** | | Having lift or not | -7.76e-4 | -6.27e-2* | 1.62e-2 | -2.07e-2 |
| | | Building age | 2.98e-4 | -1.11e-4 | -8.16e-3* | -2.00* |
| **Neighbourhood factors** | **Facility categories** | | | | | |
| | Closest metro station to the house | Distance to it | -1.66e-5 | -3.87e-5 | -1.83e-5 | -3.11e-5* |
| | Closest hospital of level 3 | Distance to it | 7.68e-5* | -2.83e-5 | 2.12e-5* | 1.29e-5* |
| **Number of Observations** | | | 478 | 375 | 754 | 623 |
| **λ** | | | 0.7727 | 0.3955 | 0.7388 | 0.6707 |
| **AIC** | | | -379.97 | -257.72 | -461.84 | -569.57 |
| **AIC for OLS** | | | -336.46 | -256.53 | -413.58 | -539.92 |

**Table 11** Summary of SEM for Each of the Four Administrative Districts
Note: "*" represents the 5% significant level.

According to **Table 10**, the effects of the closest primary schools in all administrative districts are all insignificant. Then, density of non-general primary schools does not have significant effects, either. These results all contradict to the previous result for the whole four districts, which requires further investigation.

(1) Best middle school within the school-district

With regard to the best middle school within the school-district, the quality of such middle schools have significant effects on housing prices in Xicheng and Chaoyang. However, in Dongcheng and Haidian, such effects are insignificant. According to the middle school enrolment policies in Dongcheng, only after the random designation in the whole administrative district ends could students take part in another random designation process within each school-district. In this case, students have less opportunity to be enrolled to the best middle school within the school-district. In Haidian, students could take part in the "registration enrolment" before being randomly designated to middle schools within school-districts. During the registration enrolment process in Haidian, students are allowed to choose three schools they are most interested in within the "enrolment district" (In Haidian, this is a kind of district which contains several school-districts), which allows students to choose high quality schools in a wider scope. Thus, best middle schools within school-districts of Haidian are not so attractive.

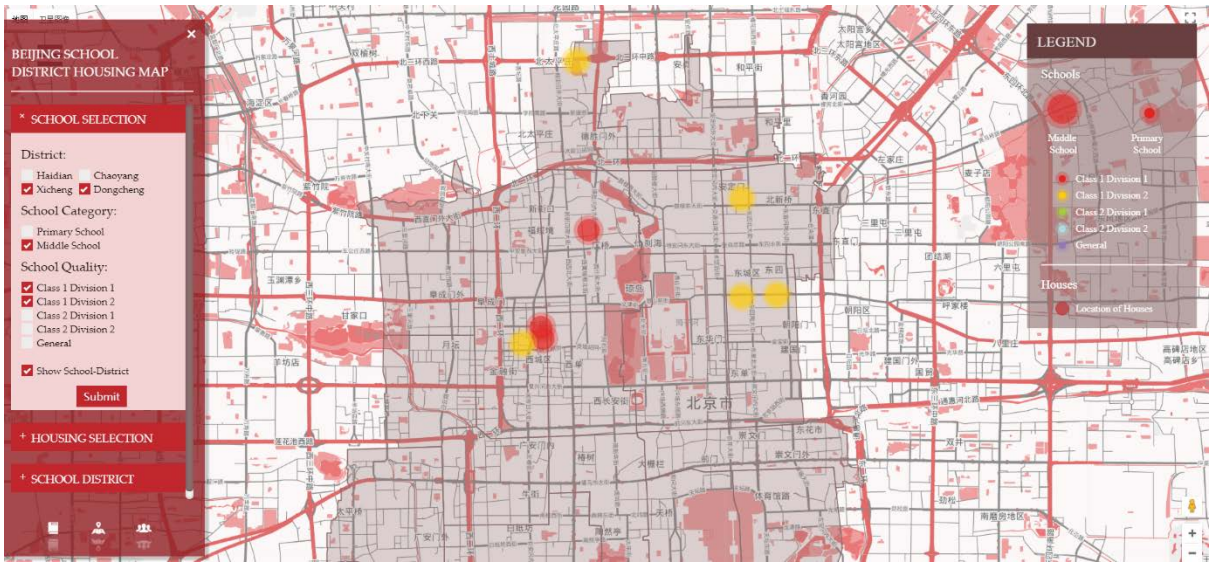


**Figure 10** Location of the Best Middle Schools of Xicheng and Dongcheng District

The effects of distance to the best middle school within the school-district are significant in only Chaoyang and Haidian. This is mainly due to the large area of school-districts in these two districts, for example, *Wenquansujiatuo* in Haidian and *Cuigezhuang* in Chaoyang, where students may live too far away from the best middle schools within these school-districts. Too long distance from the school will thus have negative effects on housing prices. On the contrary, most of the school-districts in Xicheng and Dongcheng are around $5km^2$, which could cover the scope of walking distance. So, the distance to the best middle school in Xicheng and Dongcheng does not significantly affect housing prices.

The distance to the best middle school within a specific administrative district has significant influence on housing prices in all four administrative districts. In Xicheng and Dongcheng, the best middle schools are all clustered near the Imperial Palace, the centre of Beijing. Living near these middle schools means to be closer to the urban centre, and thus housing prices are higher. In Haidian, the best middle school is the Affiliated Middle School of Renmin University of China, located in Zhongguancun, where the highest quality educational resources cluster. Living near Zhongguancun implies higher chance of receiving these educational resources, which increases the housing prices. In Chaoyang, two of the best middle schools are located near the Olympic Park and Sanlitun (a famous commercial centre in Beijing) respectively, which also play important roles in increasing housing prices.

(2) Closest middle school

As for the closest middle school to each house, none of the administrative districts' housing prices are significantly affected by their quality and the distance to them, except Dongcheng, in which distance to the closest middle school has significant effects on housing price. The reasons for these insignificance needs further investigation.

## 7. Conclusion

This study focuses on the relationship between schools and housing prices in the four administrative districts in central Beijing by applying the hedonic price model and spatial econometric models. The results could be concluded into three parts: school density factors, primary school factors and middle school factors.

First, the density of both non-general primary and middle schools could positively affect housing prices.

Next, quality of closest primary schools could make a difference on housing prices because of the nearby enrolment policy, whereas the distance from the house to the closest primary schools does not.

Then, effects of three kinds of middle schools are discussed. For the best schools within school-districts, their quality have significant effects on housing prices in Xicheng and Chaoyang, while housing prices in Dongcheng and Chaoyang are not affected. Distance to these schools only affect housing prices in Chaoyang and Haidian as the area of some of the school-districts in these two administrative districts are very large. For the best schools within administrative districts, higher quality of the top school of an administrative district would increase the housing prices in that district. And the distance from residence to these top schools has huge effects on housing prices in all four administrative districts. For the middle school closest to a house, neither the quality of school nor the distance between the school and the house would affect housing prices.

However, some contradict results exist during the analysis, which requires further investigation in following studies.

## 8. Limitation & Further Extension

This research contains some limitation.

First, more factors need to be taken into account. Due to the complicated enrollment policies in four administrative districts, this research could not cover all the policy details and may omit some other school factors, such as the scale of schools, teaching resources, etc. Moreover, the housing price is affected by many factors, such as location, surrounding infrastructures, transportation, etc. However, this research only considers a portion of these factors, which might still lead to biased results despite the application of spatial econometric models.

Next, the data of housing price only comes from one website, Lianjia. Information from only one website may be biased because of the monotonous target group of one website, which may lead to biased analysis results.

Furthermore, due to the security policies in China, the coordinates from Chinese maps will be deviated on the Google map. It leads to the incorrect location of some points on the visualization map.

Some further extensions could be made to improve the research and the website.

In the website, the popup section could show more information about analyzing results which could clearly present the correlation between schools and housing prices.

Then, the website could attempt to achieve real-time upgrading data in order to observe the changes of housing prices as the policies are changing. With these updating data, the website could even help parents to gain more detailed information about schools to make optimal choices for their children’s education.

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## Appendix

- Data Source

| Source | Explanation |
|---|---|
| **https://www.lianjia.com/** | Lianjia -- Chinese biggest property trade website. |
| **http://www.bjdata.gov.cn/** | Beijing Municipal Administration Data Resource Website |
| **http://www.eol.cn/** | Chese Education |
| **http://www.xschu.com/** | Beijing Xiaoshengchu |
| **http://jw.beijing.gov.cn/** | Beijing Municipal Education Commission |
| **http://lbsyun.baidu.com/** | Baidu map API |

- API Endpoints and Examples

| **API name** | **Endpoint** |
|---|---|
| Get all school data | http://dev.spatialdatacapture.org:8890/data/all |
| Get specific school data | Endpoint:<br>http://dev.spatialdatacapture.org:8890/data/:District/:School category/:School quality<br><br>Example:<br>http://dev.spatialdatacapture.org:8890/data/Haidian/Primary/1 |
| Get school districts data | Endpoint:<br>http://dev.spatialdatacapture.org:8811/:DITRICT<br><br>Example:<br>http://dev.spatialdatacapture.org:8811/Haidian |
| Get specific houing price data | Endpoint:<br>http://dev.spatialdatacapture.org:8890/data/price/:District/:Upper year/:Lower year/:Maxium price/:Minum price/:Lift or not<br><br>Example:<br>http://dev.spatialdatacapture.org:8890/data/price/Haidian/2008/1990/90000/20000/1 |