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How Does the Quality of Junior High Schools Affect Housing Prices? A Quasi-Natural Experiment Based on the Admission Reform in Chengdu, China

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Abstract: We exploit an admission reform of junior high schools in Chengdu, China, to identify the capitalization effect of high-quality educational facilities on housing prices. Since 2013, some elite junior high schools have conducted an experimental policy called the four-year junior high school project (hereinafter referred to as FJHP). The FJHP reduced the admission chances to elite junior high schools within the FJHP school districts via lottery. Based on 88,745 resale housing transaction records from Chengdu during 2010–2018, we used the difference-in-difference (DID) methodology to estimate the average price effect of the FJHP. Furthermore, we established a DID model with quantile regression to estimate the heterogeneous effect of the FJHP on housing prices. The empirical results show that the implementation of the FJHP reduced the housing prices in the relevant school districts by at least 5.5%, and its price reduction effect increased over time. The quantile regression results show that households with high-priced housing are more sensitive to the change of admission chance to elite junior high schools, which indicates the inequality in accessing high-quality school facilities under the designating admission zone policy. This study concludes with implications for improving the accessibility of school facilities.



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Keywords: capitalization; housing prices; school facilities; difference-in-difference; quantile regression

1. Introduction

Social infrastructures include facilities for education, healthcare, culture, sport, recreation, and public green space [1,2]. They are the vital providers of public goods. Social infrastructures in urban areas accelerate the agglomeration of enterprises and populations, which promote economic prosperity and have significance for social progress [3,4]. Therefore, social infrastructures have always been a focus of discussion in economics.

The rapid growth in China's urban population in recent years has resulted in the growing demand for public goods and a lack of social infrastructures. Residents may compete for scarce local public goods through housing purchases, which allows the value of social infrastructures to be capitalized into housing prices [5]. Therefore, targeted measures for the greater accessibility of social infrastructures are needed to fulfill the increasing demands of people. However, the first step is identifying the implied value of social infrastructures in housing prices.

Among the various types of social infrastructures in urban areas, school facilities may be one of the most important. Basic educational resources are highly competitive in China, which means that housing in a good school district contains a great deal of premium [6]. Recently, China implemented the principle of “examination-free enrollment and nearby enrollment” during students' nine-year compulsory education. To equalize the basic public education services, the government has delineated fixed borders of admission zones for each school. Therefore, admission opportunities are linked to residents' household registration or house ownership in a specific area. Residents can obtain admission into a specific school by purchasing housing, which has led to the booming market transactions

of school district housing and the soaring price of school district housing in elite schools. In this regard, the Ministry of Education demanded that every city “adopt multi-school zoning actively”. “Multi-school zoning” means merging the admission zones of several schools into one. It was designed to ensure the equalization of education quality among all areas by distributing each popular primary and junior high school into different admission zones. Households in a multi-school district must obtain their admission qualifications for specific schools via a lottery.

Multi-school zoning weakens the one-to-one correspondence between house ownership and a specific school. However, the opportunity to enter elite schools without examination may still attract parents to school district housing, even though this is not 100% reliable. Thus, the high price of school district housing and the uneven distribution of educational resources may not be fundamentally changed. The 19th National Congress of the CPC report pointed out that educational equity is an important basis for promoting social equity. How to more effectively control the high premiums attached to school district housing is a major concern in educational reform. “Houses are for living in, not for speculation” is also a national goal of the housing policy. Therefore, by accurately identifying the value of high-quality school facilities in the case of multi-school zoning, we can discover whether this policy has effectively achieved its initial goal.

We try to identify the accurate value of high-quality school facilities by observing the changes in housing prices under fluctuations in policy. Since 2013, some junior high schools in Chengdu have received approval from the government to conduct an experimental policy called the four-year junior high school project (FJHP). The FJHP allowed junior high schools to provide admission quotas for 5th-grade students in primary schools, and extend the schooling period from 3 to 4 years. Furthermore, the most important change the FJHP made to admissions was replacing the lottery with an examination, reducing the chance of elite junior high school admission achieved by residential purchasing. Therefore, the FJHP allowed us to accurately identify the value of elite junior high school admission opportunities under multi-school zoning and random lottery.

Additionally, the FJHP provided a sample that can be used to observe whether administrative-based measures can simultaneously achieve educational equality and make urban housing more affordable. Therefore, we used the difference-in-difference (DID) methodology and take the FJHP in Chengdu as a quasi-experiment to empirically estimate the impact of the FJHP on school district housing. To obtain an accurate estimation of the results, we collected more than 80,000 resale housing transaction records in the urban area of Chengdu from 2010 to 2018. We also discussed the mechanism of influence between admission reform and educational resource allocation by combining DID and quantile regression. The remainder of this paper is structured as follows. In Section 2, we discuss the related literature. In Section 3, we present the theoretical framework and hypotheses. In Section 4, we outline the data, variables, and empirical models utilized in the study. In Section 5, we discuss the empirical results. In Section 6, we provide conclusions and the implications of the results.

2. Literature Review

Social infrastructure accessibility plays an essential role in raising housing prices [7]. Social infrastructures promote regional economies, urban population, and average income by providing public goods, which increases housing demand and prices in a city [8–10]. The social infrastructures themselves can also directly influence housing prices in the nearby area [11–13]. Tiebout was the first researcher who provided a theoretical analysis of the impact mechanism between public goods supply and housing prices in 1956. He pointed out that the supply of urban public goods affects housing prices via consumers’ housing choice behavior, which is called the “vote with your feet” theory [14]. Oates verified that the local government’s investment in public goods would be capitalized into housing prices. Based on his study, Oates proposed the concept of the “capitalization” of public goods [15]. Since then, many studies have quantitatively evaluated the capitalization effects

of social infrastructures by observing the real estate market. Some studies focused on urban infrastructures' effect on housing prices from a macro perspective [16,17]. Meanwhile, more researchers paid attention to the micro-perspective, such as the capitalization effects of schools [18], water and green space amenities [19], hospitals [20], and recreational facilities [21,22] on housing prices using the hedonic price theory.

As Ross et al. and Nguyen-Hoang et al. concluded in their literature reviews, many studies with different methodologies and indicators have revealed that educational quality has a significant capitalization effect on housing prices, meaning that high-quality school facilities have an additional attraction to homebuyers [23,24]. The key issue when measuring schools' educational quality is choosing appropriate indicators. In existing studies, the indicators can be sorted into two categories: input and output. Indicators of input include faculty–student ratio, school size [25], and whether the school is classified as a key school [26,27]. Meanwhile, more studies focused on school's output indicators, such as competition and test scores [28–30] and the school's social reputation [31,32].

It is necessary to discuss possible endogenous problems when analyzing the impact of educational quality on housing prices. The first problem is omitted variables. Some important neighborhood characteristics may be unobserved, resulting in biased estimation [33–35]. Self-selection may also lead to biased estimation. For example, local governments may build schools in densely populated areas with higher housing prices to serve more residents [36]. Scholars have proposed several solutions to endogenous problems. First, the regression discontinuity design (RDD) methodology is employed to deal with the problem of omitted variables. RDD excludes the influence of other neighborhood characteristics on housing prices by controlling the boundary fixed effect (BFE) [37,38]. However, controlling BFE may still not be enough to eliminate the unobservable neighborhood characteristics gap between two school districts [39,40]. The second methodology is the instrumental variable (IV) methodology, such as using the dummy variables of school type [41], school enrollment age group [42], and whether the school has experienced an Ofsted inspection as instrumental variables to measure a school's educational quality [43]. However, in such studies, it is often difficult to find a suitable instrumental variable [23]. Since its reliability cannot be fully proven, the IV methodology is less commonly used. In recent years, quasi-experiments and the difference-in-difference (DID) methodology have been increasingly applied [44–47] to address omitted variables by identifying the housing prices impact of short-term supply and demand imbalances caused by policy fluctuations. Many educational policy fluctuations are used to measure the capitalization effects of school facilities, including the charter school opening in Atlanta [48], school redistricting in Ohio [49], the rezoning of primary school districts in Hangzhou [50], the “zero school choice” policy in Hangzhou [51], the “locking districts for senior high school admission examination” (LDHSE) in Beijing [52], and Chicago's magnet schools' proximity lottery [53].

In summary, there have been many studies on the impact that education quality has on housing prices, but limitations still exist. RDD is not necessarily applicable for identification because the boundaries of school districts in large cities in China are often fragmented. Some researchers who used DID may only have a small treatment group, while some used average housing prices within a large area as an explained variable, which cannot capture the individual characteristics of housing. Compared with the existing studies, we tried to contribute in the following aspects.

First, by using the FJHP as an exogenous shock, we could deal with the potential endogeneity caused by unobserved neighborhood characteristics. Therefore, this study accurately quantifies the value of chances for admission to elite junior high schools, which is a supplement to the existing literature discussing the relationship between school facilities and the real estate market.

Second, by using micro-transaction data, we could further ensure the robustness of the empirical results. We collected more than 80,000 resale housing records with detailed individual characteristics and neighborhood characteristics within a city, which reduced the

self-selection bias in our study to some extent. In addition, collecting housing transaction records with detailed geographical information also allows us to further analyze the relationship between other social infrastructures and the real estate market.

Third, based on the abundant micro-housing price data, we applied the quantile regression model to reveal the mechanism of educational resource distributions under the designating admission zone policy. Given that the housing transaction price reflects a household's income, we estimated the heterogeneous effects of the FJHP on households' willingness to pay in the real estate market across different incomes. Therefore, the estimators indicate whether attributes of household income disrupt educational equality under the designating admission zone policy.

Finally, our discussions on the empirical results provide new implications for ensuring the accessibility of urban social infrastructures, especially school facilities. Most of the educational policies related to housing in the existing literature one-sidedly focused on educational equality, ignoring the capitalization effects of school facilities, which often led to costly school district housing. Unlike other cities in the existing studies, the city government of Chengdu has realized the negative impact that fixed school districts have on the real estate market¹. However, its attempts at multi-school zoning to achieve educational equality and make housing more affordable were still administrative-based measures. Therefore, a discussion on the effectiveness of these measures could help to provide a reference for admission reformation in the future.

3. Theoretical Framework and Hypotheses

According to Tiebout's equilibrium analysis of public goods, local governments provide public goods of different qualities through fiscal expenditures. Under the premise of an unrestricted population flow and complete information, people will choose residential areas and corresponding public goods according to their income and preferences; areas with high-quality public goods will attract more people to settle [54,55]. When more and more people settle in areas with a higher quality of public goods, the increase in demand will only push up the prices of public goods because the supply elasticity is weak. Under the guidance of the price mechanism, residents with similar preferences regarding the quality of public goods and a similar paying ability will gather in proximity [56]. Then, the demand and supply of public goods will gradually reach equilibrium, realizing the effective and optimal allocation of public goods. Areas with better quality public goods also tend to have higher housing prices. The "voting with your feet" theory makes it possible to use housing transaction data to estimate the implied price of high-quality school facilities. In the last four decades, China has experienced rapid industrialization, which has greatly increased the demand for highly educated workers in all walks of life. Industrialization in China has also widened the income gap among residents. Thus, the economic returns on investments in education have become high [57]. The scarcity of high-quality educational resources and the unbalanced distribution of school quality and admission chances have triggered fierce competition among residents for high-quality educational resources. Finally, residents' valuation of opportunities, for example, the peer effect of other students in the school, plays an essential role in housing prices [58,59]. The vast majority of schools in China's compulsory education are public. The local government not only invests in establishing public schools, but also designates fixed admission zones for each school based on the principle of "examination-free and nearby enrollment". It created so-called "school districts", which bounded the relationship between admission opportunities and house ownership. Multi-school zoning with a lottery may evenly distribute the capitalization effects of high-quality educational resources over a broader range, while the educational quality of different schools greatly differs within the same multi-school district. However, admission opportunities are still based on house ownership. The FJHP partly changed this situation. It took some of the quotas from the regular lottery admission, which reduced the chance of admission in the random lottery. Therefore, regarding the impact of FJHP on housing prices, we propose the following hypotheses:

Hypothesis 1. *The FJHP reduced the capitalization effect of high-quality educational resources on housing prices.*

Given the strong correlation between the quality of schools and housing prices under the designating admission zone policy, wealthy households may easily obtain access to better housing and popular school facilities. However, low-income households would face uneasy trade-offs between house ownership and the chance of admission to popular school facilities. Usually, they have to reduce their educational needs to prioritize affordable housing. Therefore, households with different income levels may have varying residential consuming behaviors regarding the changes in chances of admission to elite schools. We further propose the following hypothesis for the heterogeneous impact of the FJHP:

Hypothesis 2. *The FJHP has more influence on the price of high-priced housing.*

4. Research Methods and Data Sources

4.1. Empirical Model

The FJHP implementation dates among different schools are inconsistent and do not meet the application conditions of the classic DID model. Therefore, the multi-period DID model is needed. In order to estimate the effect of the FJHP on housing prices, which is Hypothesis 1, we adopt a multi-period DID model with fixed effects:

$$\ln P_{it} = \beta_0 + \beta_1 FJHP_{it} + \lambda_j + v_t + \sum_{x=1}^n \alpha_x Z_{xit} + \varepsilon_{it} \quad (1)$$

where the subscript i represents housing i in the community j , t represents the transaction period, and $\ln P_{it}$ is the natural logarithm of the housing prices (CNY/m²). $FJHP_{it}$ is a dummy variable for policy implementation grouping. $FJHP_{it} = 1$ if the housing i in the community j is located inside the FJHP area in period t (half year each period), and $FJHP_{it} = 0$ if the housing i in the community j is located outside the FJHP area in period t . λ_j represents the community fixed effect, v_t represents the half-year fixed effect, Z_{it} represents a series of other control variables, and ε_{it} is the error term. Parameter β_1 is the key indicator to estimate the impact of FJHP on housing prices.

4.2. Variable Selection

(1) Explained variables. The explained variable is the logarithm of the resale housing transaction price (CNY/m²). Compared with the newly built housing market, the resale housing market is closer to a perfectly competitive market in China. The number of real estate developers is limited, while any house owner can be a potential supplier in the resale housing market. Therefore, the resale housing transaction prices better reflect the actual market supply and demand. We obtained 90,881 historical transaction records of resale houses in 660 communities in the central city of Chengdu from 2010 to 2018 through real estate agency websites (<https://cd.lianjia.com>, accessed on 11 April 2020; <https://m.lufangjia.com>, accessed on 23 December 2021). Each transaction record contains a list price and a final transaction price, and we chose the latter as the explained variable.

The sampled communities were evenly distributed geographically, and generally covered school districts of different educational quality. When collecting transaction records, we mainly chose those in elevator apartments and those less than 15 years old to control the building status' heterogeneity. After removing housings that were too large (>190 m²) or too small (<50 m²)² and repeated transaction records, 88,745 valid records remained. In addition, we took the logarithm of the house price to absorb the fluctuations in the nominal price over the years into the intercept β_0 .

(2) Control variables. To control the variables of housings' individual characteristics and neighborhood characteristics, the collected transaction records' data include detailed information of the housing. Control variables include the built-up year, transaction date, and building area, plus the quality of junior high schools and primary schools, city center distance, Metro distance, commercial characteristics, cultural characteristics, ecological

characteristics, medical characteristics, building area, and house age. Table 1 presents a detailed description of all of the control variables.

Table 1. Variable description.

Category	Variable Name	Variable Definition	Variable Value or Unit
Explained variable	<i>LNprice</i>	Housing transaction price per square meter	Take logarithm
Core explanatory variables	<i>FJHP</i>	The implementation of the “four-year junior high school project”	Affected = 1; Unaffected = 0
	<i>Middle</i>	Education quality level of housings’ corresponding junior high school district	Five levels in total
Educational characteristics	<i>Primary</i>	Education quality level of housings’ corresponding primary school district	Five levels in total
	<i>LNcentral</i>	Shortest straight-line distance to the city center CBD	Take logarithm
Neighborhood characteristics	<i>LNmetro</i>	Shortest straight-line distance from the subway station	Take logarithm
	<i>Market</i>	Number of large commercial complexes within 1.5 km	
	<i>Culture</i>	Number of cultural facilities (stadium, museum, university, theater, etc.) within 1.5 km	
	<i>Ecology</i>	Number of large parks or green spaces within 1.5 km	
Building characteristics	<i>Hospital</i>	Number of tertiary hospitals within 1.5 km	
	<i>Area</i>	Area of housing	m ²
	<i>Age</i>	Housing transaction date minus built-up date	Half-year
Fixed effects	<i>Community FE</i>	Community fixed effect	A total of 660 communities
	<i>Time FE</i>	Time fixed effects	2010–2018, half year each period

4.3. Sample Selection and Data Processing

Chengdu is the capital of Sichuan Province and one of China’s most famous historical and tourist cities. The built-up area of the central city has reached 1421.6 km² and contains over 10 million people. As a central megacity in west China, the education quality of Chengdu is also among the highest in China; there are more than 150 public junior high schools in the central city. There are also no more than 20 private junior high schools, and admission into a private school does not require house ownership. However, the admission to private schools requires examinations rather than the lottery. Therefore, households have to strive for public schools anyway, regardless of the existence of private schools.

China’s housing market is mainly composed of housing communities. Each community is developed by a single real estate developer, and often accommodates hundreds or thousands of houses. Housing units in the same community usually share similar community characteristics (property management, building structure, and community facilities) and enjoy the same neighborhood characteristics. Therefore, the housing prices in the same community do not vary much. Based on 88,745 transaction records collected in 660 communities, we can control the quality of the influencing factors.

In Chengdu, “single-school zoning” is applied to primary school admission according to the principle of nearby enrollment made by the Ministry of Education. School-age students go to the nearest public primary school designated to their house. However, most junior high schools are in “multi-school zoning”. Based on the primary schools’ admission zoning, from two to five nearby junior high schools form a multi-school admission zone and enroll primary school graduates within this admission zone. Those graduates will have to obtain admission from a specific junior high school by lottery. In addition, a junior high school was often included in more than one school district. Figure 1 shows the models of the multi-school zoning in Chengdu.

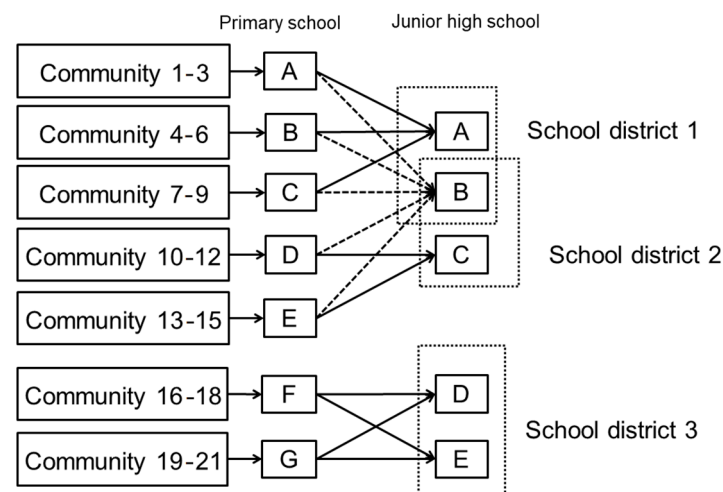


Figure 1. Models of multi-school zoning in Chengdu.

Multi-school zoning weakened the ability of elite junior high schools to screen better students due to the random assignment rule, which hurt their competitiveness. Therefore, some schools have tried to bypass the lottery and persuaded the city government to allow them to implement the FJHP. FJHP schools directly enroll students who have completed the fifth grade of primary school within their admission zone and extend the schooling period from three to four years. Thus, the FJHP is also known as “five plus four”. Its core intention is to allow elite schools to proactively screen better students and increase the grades in senior high school entrance examinations. The most critical change the FJHP made to admissions was the resumption of examinations. Therefore, the FJHP has loosened the bond between admission opportunities and house ownership, which may change the capitalization effect of educational resources on housing prices.

This study selected two public junior high schools that participated in multi-school zoning and publicly implemented the FJHP: Jinniu Experimental Middle School and Shishi Shuangnan School. More than 60% of the students’ senior high school entrance examination grades exceeded the “key mark”³ in the two schools, ranking among the top eight public schools in Chengdu. In addition, the two schools were the only elite schools in their respective school districts. The average “key rate”⁴ of senior high school entrance examination in the remaining schools of the same school districts was about 20%, which was the lowest grade among all school districts. Therefore, changes to the admission chance of the two schools will significantly affect the access of school-age students to high-quality educational resources in the school district. The housing prices within the admission zones were used as the treatment group, and the remaining housing prices were used as the control group. The starting date of the FJHP was based on the announcement date of the relevant documents of the Education Bureau of Chengdu city (Table 2). Before the FJHP, the lottery admission chance in the respective school districts of the two schools was about 24%, and the FJHP reduced this to about 12%⁵.

Table 2. Implementation time of the FJHP.

FJHP Schools	Announcement Date
Jinniu Experimental Middle School	1 September 2013
Shishi Shuangnan School	7 November 2014

We obtained the housings’ educational quality characteristics by grading the corresponding primary and junior high schools in each school district. Therefore, we searched numerous Chengdu city-level and administrative district-level school admission policy documents and the public information of each school to complete the grading. Referring to

the study of Gibbons et al. [60], we estimated the education quality of junior high school districts according to the examination grades. Specifically, for the educational quality of each junior high school district, we used the average key rates of the school districts in the senior high school entrance examination in the grading. We graded all school districts in five levels. For example, the annual key rate of Jinniu Experimental Middle School was about 60%, which was equivalent to the fourth-level school district. Referring to the study of Liu et al. [61], we estimated the quality of primary schools according to their social reputation. We also graded the educational quality of primary schools in five levels. Figure 2 shows the distribution of the housing transaction samples collected in the study and the quality of the housings' corresponding junior high school district. We obtained the neighborhood characteristics of each community using the spatial distance measurement functions of ArcGIS 10.2.

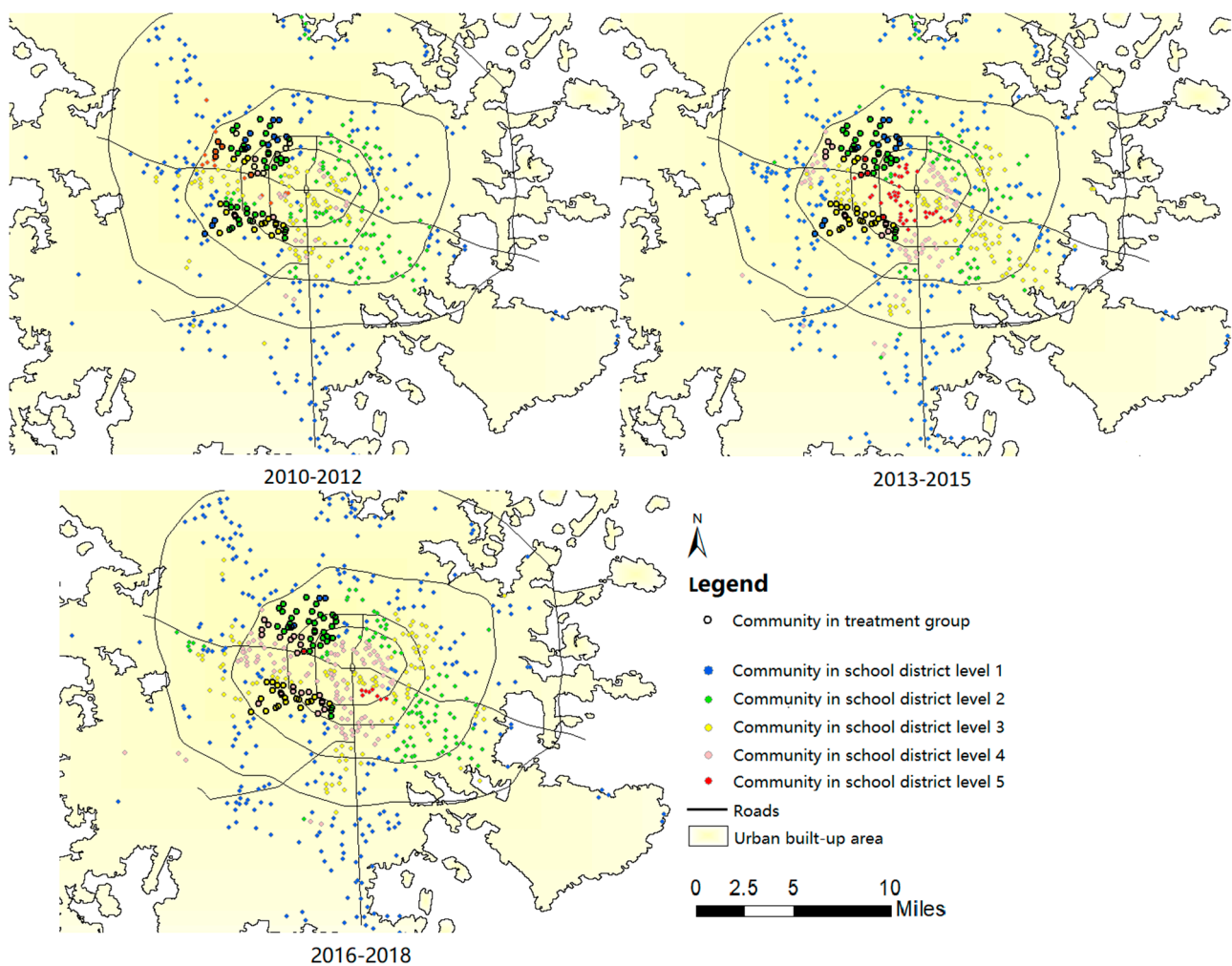


Figure 2. Distribution of study samples and their educational quality⁶.

We conducted a descriptive statistical analysis of the explained and control variables used in this study, as shown in Table 3. These descriptive statistics indicate the differences in housing prices and control variables between the treatment group and the control group, as well as the variations in these variables over different periods. Housing prices in FJHP districts were not significantly different from the average price of all samples in 2010–2012, but were overtaken by the average price in 2013–2018. The differences in the control variables between the FJHP districts and the comparisons were also not very noticeable.

Table 3. Descriptive statistics of the variables.

	2010–2012				2013–2015				2016–2018			
	All Samples		Treatment Group		All Samples		Treatment Group		All Samples		Treatment Group	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
<i>Housing price per area</i>	8531	1907	8732	1337	8927	2247	9232	1720	14,193	5844	13,566	4379
<i>Area</i>	95.487	28.317	93.02	31.11	98.05	27.05	94.41	28.7	94.43	26	93.57	28.18
<i>Age</i>	5.08	3.02	4.68	4.06	5.25	4.36	7.68	4.06	8.25	4.36	10.68	4.06
<i>Middle</i>	1.47	1.23	1.57	1	1.69	1.15	1.67	0.92	1.86	1.04	1.72	0.87
<i>Primary</i>	1.47	1.24	1.84	0.93	1.88	1.36	2.19	0.92	2.17	1.25	2.53	0.83
<i>LNcentral</i>	7.84	3.47	7.27	1.25	7.96	3.53	7.26	1.23	8.05	3.54	7.26	1.23
<i>LNmetro</i>	4.46	3.33	3.85	1.19	2.67	2.63	2.52	1.37	1.44	1.47	1.09	0.86
<i>Market</i>	0.82	2.06	0.89	0.92	1.23	2.68	1	0.93	1.41	2.65	0.97	0.79
<i>Culture</i>	0.51	1.09	0.65	0.85	0.54	1.11	0.68	0.89	0.6	1.16	0.7	0.91
<i>Ecology</i>	0.97	1.19	1.29	1.18	1.14	1.19	1.37	1.14	1.25	1.19	1.48	1.11
<i>Hospital</i>	0.54	1.11	0.72	1.05	0.68	1.28	0.8	1.14	0.89	1.54	0.87	1.22

5. Empirical Results and Discussion

5.1. Results of the DID Models

Based on the DID model, we carried out a regression analysis of the resale housing price data before and after implementing the FJHP. The data cover the period from the first half-year of 2010 to the second half-year of 2018. There was a time from the announcement of the FJHP to the dissemination of news and the market response. Therefore, we took the current half-year in which the policy is announced as the zeroth period. Table 4 shows the estimated results of the FJHP's impact on the housing prices in the school district. We divided the regression results into two groups: the first group comprised columns (1)–(3), which formed the benchmark results of the DID model. The second group comprised columns (4) and (5), and the primary school quality was used as a dummy variable. The primary school's educational quality will affect the quality of students in junior high schools, so we can exclude the student factors by controlling this. Column (1) shows the regression result without half-year fixed effects and community fixed effects, column (2) shows the regression result with both of these, and column (3) shows the result with all control variables removed. Column (4) includes all control variables and takes the quality of primary schools as a dummy variable, and column (5) removes all control variables except the dummy variable for primary schools. It can be seen from Table 4 that all β_1 values are at least around -0.055 , whether or not the control variable is added. All β_1 values are significant at the 1% level, and the FJHP's effect is more evident after excluding the interference from primary school educational quality. The estimators indicate that the FJHP has caused at least a 5.5% price reduction in the housing within the FJHP districts, verifying Hypothesis 1. The DID results verify that a 12% admission chance to an elite junior high school generates a premium of 5.5% in the school district's housing value. In other words, the capitalization effect of elite junior high school quality on housing prices is still pretty high, even under multi-school zoning.

In addition, the estimated coefficients of *LNmetro* are significantly negative, while the estimated coefficients of *Culture* and *Ecology* are significantly positive. The proximity to a Metro station, cultural facilities, and ecological facilities may also increase the surrounding house prices. The estimators of the control variables indicate that cultural and ecological facilities also have capitalization effects on housing prices, which reveal residents' desire for a better quality of life. However, the estimated coefficients of hospitals are significantly negative, which could be interpreted as the benefits that proximity to a hospital provides to residents cannot offset its disamenity.

Table 4. Effect of the FJHP on housing prices in the FJHP school districts.

Variables	(1)	(2)	(3)	(4)	(5)
<i>FJHP</i>	−0.059 *** (0.011)	−0.055 *** (0.010)	−0.056 *** (0.010)	−0.059 *** (0.010)	−0.058 *** (0.010)
<i>Area</i>	−0.000 (0.000)	−0.000 ** (0.000)		−0.000 (0.000)	
<i>Prim</i>	0.069 *** (0.004)	0.006 (0.008)		−0.006 ** (0.003)	
<i>Middle</i>	0.041 *** (0.004)	−0.006 ** (0.003)			
<i>Age</i>	0.001 *** (0.000)				
<i>LNcentral</i>	−0.239 *** (0.014)	0.005 *** (0.001)		0.021 ** (0.009)	
<i>LNmetro</i>	0.023 *** (0.001)	−0.005 *** (0.001)		−0.005 *** (0.001)	
<i>Market</i>	0.000 (0.002)	0.003 (0.003)		0.003 (0.003)	
<i>Culture</i>	0.015 *** (0.004)	0.026 *** (0.008)		0.028 *** (0.008)	
<i>Ecology</i>	0.024 *** (0.003)	0.043 *** (0.006)		0.044 *** (0.006)	
<i>Hospital</i>	0.004 (0.003)	−0.016 *** (0.006)		−0.014 ** (0.006)	
<i>Community FE</i>	No	Yes	Yes	Yes	Yes
<i>Time FE</i>	No	Yes	Yes	Yes	Yes
Observations	88,745	88,745	88,745	88,745	88,745
R ²	0.524	0.877	0.874	0.877	0.874

Note: The robust standard errors of the variables are in parentheses, **, and *** indicate significance levels of, 5%, and 1%, respectively.

5.2. Results of Robustness Tests

(1) Parallel trend test. The policy effect β_1 estimated by DID may not be the real policy effect. Its results could be caused by the original differences between the treatment and control group themselves. Therefore, the application of DID must meet the parallel trend assumption, and it is necessary to test whether the treatment group and the control group had the same trend before the FJHP. Therefore, we conducted a parallel trend test. Referring to the study of Shi et al. [62], we used the Event Study methodology. Taking the last period before the implementation of the FJHP as the base period, we selected five periods before and seven periods after the implementation of the FJHP. Figure 3 plots the estimated results of β_1 in each half-yearly period under the 95% confidence interval. Estimators of the parallel trend test indicate that before implementing the FJHP, $\beta_1 \times period$ was not significantly different from 0. $\beta_1 \times period$ began to be significantly negative under the 90% confidence interval one year after the implementation of the FJHP. Two years after the implementation of the FJHP, $\beta_1 \times period$ was significantly negative under the 95% confidence interval, and its absolute value continued to increase over time.

The result of the parallel trend test verifies that the difference in housing prices between the treatment and control groups was quite stable before the FJHP started. However, it significantly increased just after the FJHP, confirming the parallel trend assumption.

The result also verifies that the policy effects on reducing housing prices lagged and had continuity. The housing prices within the FJHP school districts did not drop significantly until one year after the implementation of the FJHP. However, the price reduction effect continued for a long time and then gradually increased. The current admission policy adjustment did not attract widespread attention until the next admission season, and it took some time for the market to react. After the steady implementation of the FJHP, a continuously expanding policy effect could be seen on the real estate market.

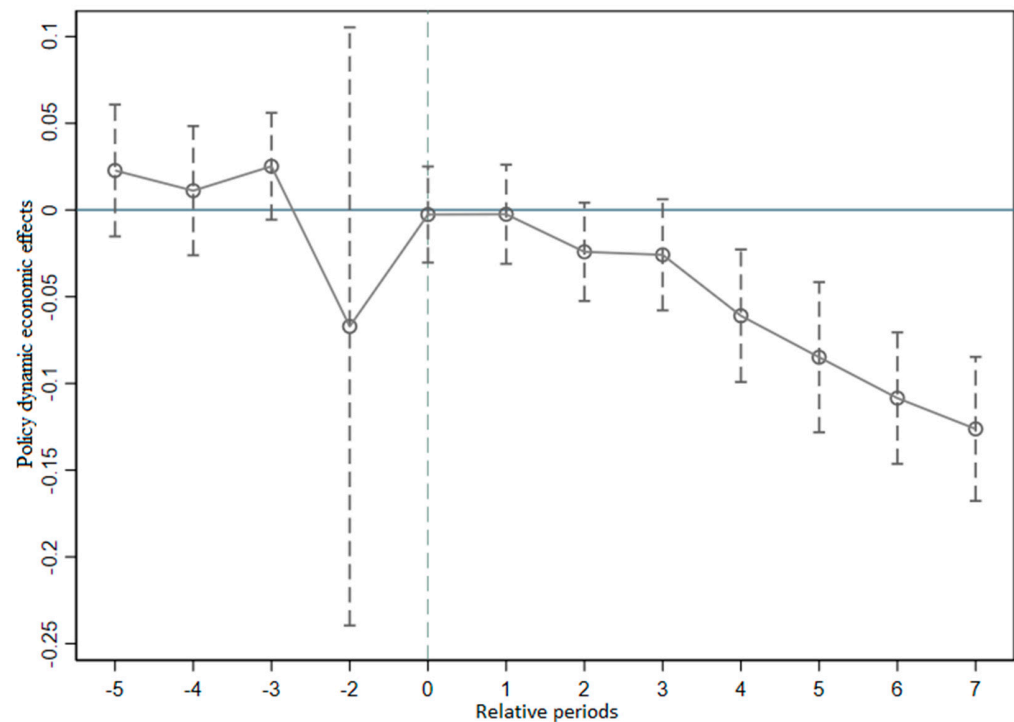


Figure 3. Results of parallel trend test.

(2) Placebo test. The parallel trend test may rule out the endogeneity to some extent, but the estimated of β_1 could still be interfered with by other policies or some unobservable random factors. Therefore, we conducted a counterfactual test as a placebo test to rule out this possibility.

Table 5 reports the estimated results for the counterfactual test. First, drawing on the study of Liang et al. [63], we conducted a regression with a fictitious policy time and treatment groups. Next, we selected the sample interval from 2010 to 2014 when there was no effect, and assumed that the FJHP was implemented 1 year earlier, 1.5 years earlier, and 2 years earlier. The regression results for the fictitious policy date are shown in columns (1)–(3). Then, we assumed that all junior high school districts with an educational quality level not lower than level 5, level 4, and level 3 have implemented the FJHP, whose regression results are shown in columns (4)–(6). The results of the counterfactual tests indicate that none of the fictitious policy effect coefficients were significantly different from 0.

Table 5. Placebo test results for fictitious policy date and fictitious treatment groups.

	Fictitious FJHP Implementation Date			Fictitious FJHP Implementation Zone		
	(1)	(2)	(3)	(4)	(5)	(6)
	1 Year in Advance	1.5 Year in Advance	2 Year in Advance	Level 5	Level 4 and Above	Level 3 and Above
Assumed FJHP	−0.003 (0.025)	0.008 (0.028)	0.007 (0.036)	0.0339 (0.034)	0.007 (0.022)	0.013 (0.013)
<i>p</i> -value	0.910	0.774	0.852	0.325	0.766	0.333
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Community FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,841	10,841	10,841	88,745	88,745	88,745
R ²	0.066	0.066	0.066	0.725	0.725	0.725

Note: The robust standard errors of the variables are in parentheses.

We also conducted another placebo test by randomly assigning treatment groups. Drawing on the study of Ren et al. [64], we randomly selected 80 communities as a fictitious treatment group in all 660 communities. We assumed that the corresponding schools in these 80 communities implemented the FJHP, and the rest of the communities were the control group. In order to eliminate the influence of random small probability events on the placebo test, the sampling was repeated 500 times. Then, we regressed each fictitious treatment group according to model (1) to obtain 500 regression coefficients of the core explanatory variables. Figure 4 plots the distribution of the 500 estimated coefficients and their p -value. Most of the estimated coefficients were distributed to be around 0 and the p -value was bigger than 0.1, while the estimated value in this paper is an obvious outlier in the figure. The placebo test results indicate that this paper's estimators are unlikely to be caused by chance factors or omitted variables.

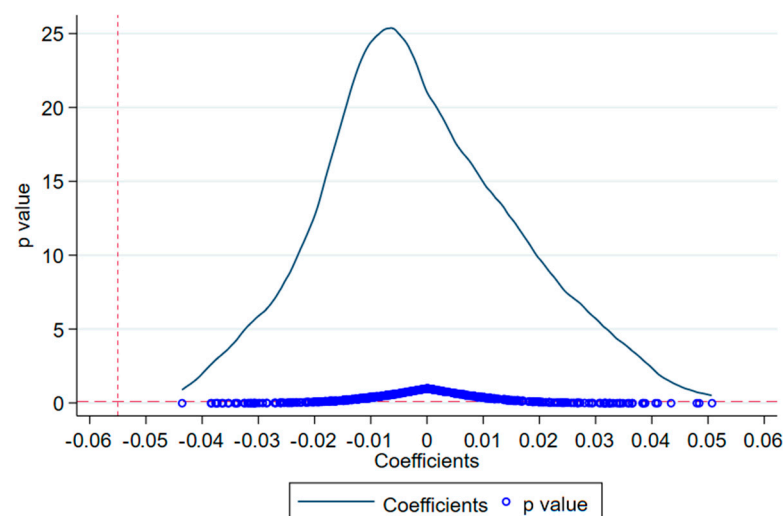


Figure 4. Placebo test results for random assignment of treatment groups.

5.3. Results of Heterogeneity Regression

(1) Model setting. The DID results only show the average price reduction effect on the entire real estate market. However, according to Hypothesis 2, the FJHP may have heterogeneity effects on the residential consuming behaviors of households with different income levels. The discussion of this issue is helpful to understand the mechanism and boundary conditions that the impact of school facilities has on housing prices and to indirectly examine the fairness of the current admission policy. In this regard, drawing on the study of Wen et al. [65], we further used quantile regression to estimate the variation in the capitalization effects and improve the DID model. We used different transaction prices per quarter meters and total prices as the quantile, and the model settings are as follows:

$$\ln P_{it} = \beta_0(q) + \beta_1(q)FJHP_{it} + \lambda_j + v_t + \sum_{x=1}^n \alpha_x(q)Z_{it} + \varepsilon_{it} \quad (2)$$

where q represents the corresponding housing price quantile; $\beta_0(q)$, $\beta_1(q)$, and $\alpha_i(q)$ are the estimated coefficients under the q th quantile; a total of five were set to 0.1, 0.3, 0.5, 0.7, and 0.9 quantiles, representing housing whose transaction price is higher than the remaining 10%, 30%, 50%, 70%, and 90%; and the remaining variables were the same as before.

(2) Analysis of results. Table 6 shows the results of the quantile regression. The estimators indicate whether this is the price per quarter meters or the total price of the house. The policy-effect regression coefficient $\beta_1(q)$ is not significantly different from 0 in the 0.1 quantile of all house prices, but is significantly negative in the 0.3 quantile. Furthermore, its absolute value continues to increase as the price quantile increases. The quantile regression results confirm that most housing prices are affected by high-quality educational resources, and high-quality educational resources have a non-linear relationship with housing at

different price levels. The price sensitivity of high-priced housing is higher than that for low-priced housing under the FJHP. The results, in turn, prove that the higher the household's income, the stronger its willingness to pay and its ability to acquire high-quality educational resources. Therefore, the “Matthew effects” in education [66] may still exist in the current multi-school zoning admission policy to some extent. Competition for education resources through housing choices may increase education access inequality. For example, upper-class households in Paris can more easily maintain proximity to high-quality educational resources through house ownership [67].

Table 6. Heterogeneous effect of the FJHP on housing prices in the FJHP school districts.

	(1)	(2)	(3)	(4)	(5)
	0.9th Quantile	0.7th Quantile	0.5th Quantile	0.3th Quantile	0.1th Quantile
Policy effects on housing prices per area	−0.079 *** (0.024)	−0.067 *** (0.016)	−0.056 *** (0.016)	−0.045 ** (0.023)	−0.032 (0.036)
<i>p</i> -value	0.001	0.000	0.000	0.050	0.373
Policy effects on total housing prices	−0.079 ** (0.035)	−0.063 *** (0.024)	−0.051 *** (0.018)	−0.036 * (0.019)	−0.018 (0.030)
<i>p</i> -value	0.026	0.009	0.005	0.055	0.541
Control variables	Yes	Yes	Yes	Yes	Yes
Community FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes

Note: The robust standard errors of the variables are in parentheses, *, **, and *** indicate significance levels of 10%, 5%, and 1%, respectively.

5.4. Discussion

Using the DID method, we empirically tested the effect of the FJHP on housing transaction prices within the admission zones of two elite schools. In total, 88,745 resale housing transaction records in Chengdu from 2010 to 2018 were taken as the research sample. We found that after the chance of school-age students entering the school district by lottery was reduced from about 24% to 12%, there was at least a 5.5% price reduction in the corresponding houses. A series of robustness tests also support the robustness of the conclusion. Then, we deeply explored the impact mechanism of educational quality differences on housing prices by combining the DID method and quantile regression. The effects of the FJHP were significantly heterogeneous regarding the housing prices at different price levels; households of high-priced housing are more willing to pay a premium for admission opportunities in elite schools. Quantile regression results indicate that household income is important when accessing elite junior high schools. In addition, according to the results of the DID model, homebuyers also pay attention to other social infrastructures, such as cultural and ecological facilities, indicating the significant influence that residents' desire for better life quality has on the real estate market.

Our empirical results indicate that multi-school zoning did not appear to achieve its initial purpose. It was not effective enough to achieve educational equality among households of different incomes or make housing more affordable. The most important explanation for this phenomenon is that administrative-based measures alone are inefficient in distributing educational resources. The admission zone for each school, whether this is the border of a multi-school or single-school district, is not naturally formed by the market, but delineated by local governments. According to the principle of nearby enrollment, local governments distribute educational resources according to specific house ownership. However, households still can “vote with their feet” in the real estate market, which exacerbates the capitalization effects of educational resources on housing prices. Therefore, the delineation of the admission zones for each school has made it more difficult for low-income households to enjoy education equality.

The empirical results also indicate that the mismatch between urban social infrastructure supply and demand is significant. In China, most of the investments in social

infrastructure are made by local governments, which have generated a sizable premium on housing prices. However, real estate tax is not imposed in China, except for in two pilot cities. Local governments currently rely solely on the auction or tender income of state-owned lands, called the land-use rights (LURs) conveyance fee, to raise funds to build and maintain infrastructures. Therefore, the local government's investment in urban infrastructures is difficult to transform into their own financial benefits, eventually damaging the incentive to supply social infrastructures.

6. Conclusions and Implications

In summary, we can infer that the equal distribution and supply capacity of social infrastructures are equally important to ensure their accessibility. In terms of educational facilities, since school district-based admission is inefficient in overcoming the educational inequalities that arise from income disparities, a reformation of the school admission is required. Furthermore, policymakers should consider the correlation between social infrastructures and the housing market to promote coordinated development in their distribution and supply. In addition, policymakers should pay attention to the correlations between the effects of different social infrastructures. The positive effects that other social infrastructures have on residents will help them share better development opportunities [3], which may reduce their desire for elite schools and alleviate the competition in education to some extent.

Based on the above analysis, this study provides several policy implications. Firstly, the government should impose real estate tax to capture the resale housing price premium brought by urban infrastructures. The results of the DID model show a high educational premium in resale housing transactions brought by urban infrastructures. Building and maintaining infrastructures require continuous and high levels of financial investment. However, the LURs conveyance fee is a one-time inflow of income, which cannot offer subsequent tax revenue when the rapid urban expansion ends and resale housing transactions dominate the commodity housing market. Therefore, the real estate tax should be imposed to promote a city's long-term development.

Secondly, the educational administrative authorities should reform the school admission, replacing house ownership with examinations. According to the results of quantile regression, households with a higher income enjoy more chances to acquire high-quality educational resources under the policy of designated school districts. Therefore, letting examinations play the leading role in determining admission into high-quality schools may ensure that people at all income levels have equal opportunities to obtain a good education. The FJHP in Chengdu provided a successful example of this.

Thirdly, the social sharing of public-school facilities, for example, opening facilities that are affiliated with public schools, such as stadiums, libraries, and auditoriums, to the public during vacation should be promoted. According to the result of basic regression, the variables of some other approximate social infrastructures were significantly positive. These facilities may be a valuable supplement to China's lack of urban social infrastructures. Public school administrators could further consider the compensable service as a self-incentive in the provision of social infrastructures.

In addition, this study may have implications for policymakers in other developing countries undergoing rapid industrialization. By conducting a quasi-experiment on admission reform in Chengdu, China, we highlight the difference that admissions according to exams or by a lottery can make to housing prices in the vicinity of elite schools. The capitalization effects of school facilities on housing prices indicate significant income and educational inequality, which are common phenomena in a society undergoing rapid industrialization [32]. Therefore, other developing countries undergoing rapid industrialization may experience similar problems. This study offers a reference to increase the efficiency of household educational investments by controlling housing prices, which could help improve the country's overall education level and strengthen its national development potential.

There are still some limitations to this study. The information that can be obtained from real estate agency websites almost always focuses on houses in isolation; therefore, it is very difficult to acquire more detailed information on home buyers, such as their household income, as well as the population or crime rates in an area⁷. These factors cannot be directly observed, but they are closely related to the explained variables. Controlling more household individual characteristics could reduce self-selection bias and allow for further analysis. In addition, although we collected enough housing transaction records this time, data accessibility issues may occur in the future, which will hinder us from using the parallel trend test to ensure the robustness of the DID results. Given that, the propensity score matching (PSM) method may also be helpful, since it usually has lower requirements regarding the amount of data [68]. Therefore, we could improve the DID method with the PSM method if we had short panel data.

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Notes

- ¹ According to the Measures for Junior High School Enrollment of Chengdu in 2006, Chengdu implemented multi-school zoning in junior high school admission, which was initially called “multi-school joint lottery” in the news report (<https://news.sina.com.cn/o/2006-07-09/02469407739s.shtml>, accessed on 10 August 2022). The official statement of multi-school zoning in government public documents appeared in 2014 (<http://gk.chengdu.gov.cn/govInfoPub/detail.action?id=973927&tn=2>, accessed on 10 August 2022).
- ² Thanks to the reviewer for the hint, which helped us understand the meaning of the building area filtering. In Chengdu, the property rights of elevator apartments of less than 50 m² are mostly treated as commercial property rights rather than residential property rights, which cannot offer admission rights to schools. The residences with an area of more than 190 m² include some villas, and their property types are quite different from ordinary housings. We believe they cannot be directly compared, so the houses with too large an area were excluded as well.
- ³ The minimum admission score for “key senior high schools”.
- ⁴ The proportion of students whose scores exceeded the “key mark”.
- ⁵ According to news reports and government public documents, there are seven primary schools in Shishi Shuangnan School’s admission zone, and about 1440 primary students graduate each year. Shishi Shuangnan School enrolls about 320 students each year, of which at least 160 are enrolled by the FJHP; Jinniu Experimental School enrolled 480 of the 1850 students that graduated from 10 primary schools each year, of which 240 are enrolled by the FJHP.
- ⁶ The satellite map of Chengdu city was obtained from this website: <http://www.atlasofurbanexpansion.org/data> (accessed on 1 June 2022).
- ⁷ The population and household income data we could find in the yearbook and government working report were at the administrative district level, while crime rates were merely at the city level. Therefore, we considered the changes in these unobservable individual characteristics of resale housing transactions over time as part of the random error term.

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