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The Effect of School Quality on House Prices: Evidence from Shanghai, China

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Abstract: Understanding the housing price premium of high-quality education could be important for improving our knowledge on the formation of housing prices and potential consequences of educational resources misallocation. This paper estimates the housing price premium of high-quality primary schools in Shanghai, China. Applying the hedonic price and paired difference models with a boundary fixed effect to the house resale transaction data from January to October 2019, the study found that the housing price premium of high-quality primary school was approximately 15.6%. Moreover, the price premium of small houses was larger than that of large houses. The results suggest that high-quality education has a significant capitalization effect on housing values. This implies that the policy of restricting one student to have a seat in only one particular school within the zoning area would lead to greater education inequality and future policies should consider this effect.

Keywords: price premium; key primary school; paired difference model; hedonic price model

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1. Introduction

The capitalization of school quality into house pricing intensifies the educational inequality [1]. Educational resources are often misallocated between households with different levels of income [2]. Households with higher income can afford "school district housing", i.e., houses that allow access to high-quality schools according to the scope of key school attendance/catchment zones [3]. By contrast, households with relatively lower incomes are less likely to be able to afford "school district housing". Consequently, an uneven distribution of educational resources leads to the inequality of residents' educational rights and might further contribute to persistent income inequality across generations [4]. In this sense, estimating the price premium that high-quality schools place on houses is crucial for understanding the housing price formation in districts with key schools and misallocation of education resources [5].

This paper complements the literature by estimating the impact of high-quality primary schools on housing prices in Shanghai, China. Specifically, the paper investigates the differences in housing prices between houses associated with high-quality primary schools and those associated with ordinary primary schools, which was examined using the hedonic price model and the paired difference method with a boundary fixed effect. To further address the concern of endogeneity, the impact of high-quality primary schools on rent is estimated for comparison reasons. This paper also estimates the heterogeneous effects of high-quality primary schools on the price of houses in different areas. A dataset of 127 pairs of complexes within the attendance zones of high-quality primary schools and those in ordinary school districts in Shanghai are used in the analysis.

The paper has three contributions to the literature. First, the paper focuses on the housing price premium of key primary schools rather than other educational stages in existing studies [5,6]. The paper pays attention to primary school for three reasons. First, the quality of a primary school plays a fundamental role in later academic achievements [1]. Second, the "school district housing" is less important for junior high schools in the research area, as it is mainly valid for public schools. That is, compared to public schools, private schools can admit students with much less restriction of location. In Shanghai, private junior high schools are much better in terms of quality than public junior high schools, making public junior high schools a second choice for students and thereby undermining the importance of "school district housing". Third, "school district housing" does not apply for senior high schools in China.

Second, the paper pays special attention to the causal impact of school quality on the housing price. The common approach to estimating the housing price premium of high-quality education is the hedonic price model [7–9]. However, the model often produces biased results due to endogeneity, i.e., school district housing and ordinary housing could be different in many characteristics, which may be omitted in hedonic price model [5]. To address the endogeneity, this study used the paired difference model with a boundary fixed effect, which compared the value of houses on the opposite sides of attendance zone boundaries to estimate the causal effect [10–12]. Because the boundary fixed effect method cannot fully guarantee the absence of omitted variables [13], the study further took advantage of the policy that lessees do not have an equal right to access the school as house owners, and we estimated the impact of school quality on rents to rule out the possibility of omitted variables.

Third, the paper further contributes to the literature by estimating the heterogeneous price premium of school quality on housing values across different housing sizes. Compared with large houses, small ones allow households with relatively tighter financial constraints to receive access to key school district houses because of its lower total price. That is, there will be a larger market demand for small school district housing. Small houses are therefore more likely to come at a higher price premium compared with large houses. Estimating the heterogeneous price premium of school quality on housing values may provide more implications for policy design.

The remainder of the paper is structured as follows. Section 2 briefly reviews the literature. Section 3 introduces the methodology. Section 4 reports the descriptive statistics and estimation results. Section 5 discusses the results and is followed by a conclusion in Section 6.

2. Literature Review

The Tiebout model predicts that the provision of public goods will lead to residential sorting [14]. Thus, local public expenditures should have an impact on attracting a community and should thereby affect housing prices via resident mobility [15,16]. The Tiebout model assumes no mobility cost for residents, though such an assumption is obviously unlikely to hold in reality. As a result, whether the prediction of the Tiebout model is true (and to what extent) becomes an empirical question. A large body of literature has studied the effect of local public goods/expenditures on housing prices [17–20], among which the role of education on housing prices has attracted special attention from researchers [21–23].

Many studies have employed the hedonic price model to estimate the housing price premium of high-quality education [6,24,25]. For example, Dougherty et al. (2009) found that student testing scores in a nearby school were positively correlated with housing prices [26]. He (2017) found that an improvement in the school's academic performance led to a significant increase in the housing prices in California [27]. Wen et al. (2014) estimated the impact of many educational variables (e.g., kindergarten number, primary school quality, junior high school quality, senior high school quality, etc.) on housing prices [8]. However, the hedonic price model has always been criticized due to the inability to address endogeneity issues [1].

A more convincing approach to estimate school quality premiums on housing prices is a spatial discontinuity design or boundary fixed effect. The idea of the approach is to compare the prices of houses that are located on opposite sides of the attendance zone boundaries but close enough to each other to rule out the spatial differences [13]. Some studies have employed the approach to estimate school quality premiums on housing prices in Western cities or countries, such as Paris [28], Minnesota [29], Seoul [30], Vancouver [31], and England [32]. In general, these studies have found a slightly smaller school quality premium on housing prices than those obtained when using the hedonic price model [8].

One potential issue with the boundary fixed effect approach is that houses opposite the school attendance zone boundary could be owned by people with different preferences [33,34], e.g., houses within the school attendance zone could be better maintained because their owners may be richer or better educated. While such differences cannot be removed by the boundary fixed effect method, Bayer et al. (2007) suggested to include as many variables as possible in the estimation [33]. However, it can never be guaranteed that all differences are being controlled. Thus, some other approaches can be conducted to complement the boundary fixed effect method [13].

3. Data and Method

3.1. Data Collection

The study selected Shanghai as the study area. Shanghai is one of the mostly populated cities in China with a lot of primary schools. The large number of primary schools comes with a diversity of educational quality and social reputation. Moreover, unlike other cities, e.g., Hangzhou, where high-quality primary schools are often located together and close to each other, high-quality primary schools in Shanghai are relatively far away from each other, and there are always ordinary primary schools located in between. The cluster of high-quality primary schools poses a challenge in estimating the causal effect due to differences in location characteristics between high-quality and ordinary primary schools. The distribution of primary schools in Shanghai, however, makes it easy to find paired samples with similar locations, with one being associated with a high-quality primary school and the other location not being associated with one.

The paper restricts the analysis to the main urban districts in the central area of Shanghai, including Huangpu, Xuhui, Changning, Yangpu, Hongkou, Putuo, Jingan, and the inner-city part of Pudong. Because there is no official rank of education quality for the primary schools in Shanghai, the selection of key primary schools was based on the lists of well-recognized accounts on social media. The study selected 70 "key primary schools" (see Table A1 in Appendix A), i.e., key publicly funded primary schools from the lists with a leading teaching quality. The sampling complexes were then selected according to the attendance zones of each key primary school. Each selected complex within the attendance zones of the key primary schools was paired with a complex within a 500 m radius from the school that was outside of the attendance zones.

The study collected detailed information on all transactions of second-hand houses in the selected complexes from 1 January to 31 October 2019 from websites of main estate agencies, such as Lianjia, Soufang, and Anjuke. The complexes with less than two records of transactions were dropped from the sample. In total, 127 pairs of residential complexes were selected. The spatial location of the selected primary schools is shown in Figure 1 (refer to the green local marks). The average housing price in each residential complex was computed according to the records of the transactions. During the computation process, all transaction prices were corrected by the discount ratio presented in Table A2 in Appendix A. Additionally, the average rents in each residential complex were computed according to the advertisements of renting houses on the website.

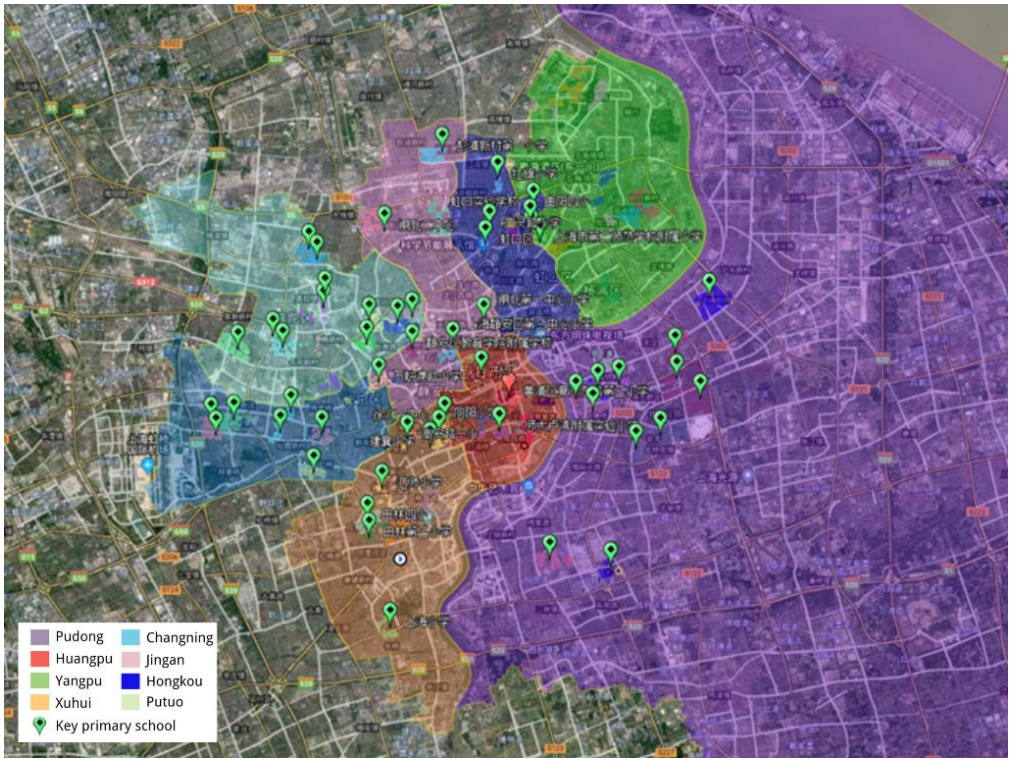

Figure 1. The location of selected key primary schools in Shanghai.

The study also collected information about the characteristics of the selected residential complexes that may affect the housing prices. Specifically, the study obtained information about building age, floor area ratio, green rate, and management service fee. The study also obtained the location characteristics of the selected residential complexes, including the distance to the nearest subway station, nearest hospital, Renmin square (an important commercial center in Shanghai), Hongqiao railway station, and key primary school. The location characteristics information were obtained using Baidu map (https://map.baidu.com/, accessed on 1 December 2019).

3.2. Empirical Method

To estimate the capitalization of the school quality on the housing price, the paper first defined the baseline model for housing price according to a hedonic price model. The model is formulated as follows:

$$Price_i = \alpha_0 + \alpha_1 \cdot X_{1i} + \alpha_2 \cdot X_{2i} + \alpha_3 \cdot School_i + \theta_i \quad (1)$$

where $Price_i$ is the average resale housing price of the residential complex i during the time period spanning from 1 January to 31 October 2019. For the purpose of robustness tests, the natural logarithms of the average resale prices were also used in the estimation. $School_i$ is a dummy variable denoting the key primary school, which is equal to one if complex i is within the attendance zone of the key primary school; it is zero otherwise. α_3 represents the coefficients of interest, which captures the key primary school's capitalization into housing prices.

X_{1i} is a vector of control variables, which captures the characteristics of residential complexes including the building age (*Year*), floor area ratio (*FAR*), green rate (*Green*), and management service fee (*Fee*) of a complex. In line with existing studies [20,35–37], this study also controlled for the locational characteristics X_{2i} of the residential complexes. The locational characteristics were measured by a complex's straight-line distance to various locations, such as the nearest subway station (*D_subway*), nearest hospital (*D_hospital*), Renmin square (*D_square*), Hongqiao railway station (*D_station*), and key primary school

(*D_school*). α_0, α_1, and α_2 are the unknown coefficients to be estimated, and θ_i is the independent and identically distributed error terms. Table 1 presents the definitions of the variables.

Table 1. Variable definitions.

Variables	Definition
Price	Average resale prices per square meter of a housing complex (RMB Yuan/m^2)
Rent	Average monthly rent per house of a housing complex (RMB Yuan)
School	= 1 if a residential complex is within the attendance zone of a selected primary school, = 0 if otherwise
Year	Building age (years)
FAR	Floor area ratio, i.e., the ratio of construction area to land area (%)
Green	Green rate, i.e., the ratio of greening area to land area (%)
Fee	Monthly management service fee per square meter (RMB Yuan/m^2)
D_subway	Straight-line distance to the nearest subway station (km)
D_hospital	Straight-line distance to the nearest (1st class 3rd grade) hospital (km)
D_square	Straight-line distance to the commercial center of Renmin Square (km)
D_station	Straight-line distance to the Hongqiao railway station (km)
D_school	Straight-line distance to the key primary school (km)

Note: Authors' own definitions.

In order to address the concern of potentially omitted variables, the study constructed complex pairs according to a boundary fixed effect method. Specifically, the study first paired each sample residential complex within a key primary school zone with a neighboring out-of-zone residential complex. Then, the study applied the paired difference model by differentiating all dependent and independent variables for the two paired complexes. Because the paired complexes shared many similar location-attached characteristics, the bias caused by the omitted location-specific factors is likely to be cancelled out. For a similar reason, the constant term α_0 in Equation (1) is also likely to cancel out. Then, the paired difference model of the house resale prices is specified as follows:

$$\Delta Price_i = \alpha_1' \cdot \Delta X_{1i} + \alpha_2' \cdot \Delta X_{2i} + \alpha_3' \cdot \Delta School_i + \theta_i' \quad (2)$$

where $\Delta Price_i$, ΔX_{1i}, and ΔX_{2i} are the differences in the housing prices and other characteristics between the paired residential complexes. In particular, $\Delta School_i$ is the difference in access to key primary school between the paired residential complexes, which is always equal to one in Equation (2). In other words, the parameter α_3' captures the key primary school's capitalization into housing price. α_1' and α_2' are coefficients to be estimated, and θ_i' is the error term.

To further test whether unobserved factors affect the results, the impact of school quality on rents is estimated according to Equations (3) and (4) as follows:

$$Rent_i = \beta_0 + \beta_1 \cdot X_{1i} + \beta_2 \cdot X_{2i} + \beta_3 \cdot School_i + \varepsilon_i \quad (3)$$

$$\Delta Rent_i = \beta_1' \cdot \Delta X_{1i} + \beta_2' \cdot \Delta X_{2i} + \beta_3' \cdot \Delta School_i + \varepsilon_i' \quad (4)$$

where $Rent_i$ is the average rent of the residential complex i at the time of data collection and $\Delta Rent_i$ is the difference in house rent between the paired residential complexes. β_0, β_1, β_2, β_3, β_1', β_2', and β_3' are the coefficients to be estimated. ε_i and ε_i' are error terms.

In principle, housing prices and rent should be both affected by the same characteristics of a residential complex. The major difference between house owners and lessees, however, is the attendance qualification of the primary school. That is, for residents within the attendance zone of key primary school, only house owners are eligible to attend the school, while lessees are not qualified [13]. Thus, if there are any omitted or unobserved factors associated with the key primary school, the variable of the key primary school will have a significant impact on the level of the rents, i.e., if β_3 and β_3' are different to zero. However, if

the impact of the key primary school on the rents is insignificant, the concern of the omitted variables should be a minor problem.

Aside from the estimation of the main effect of high-quality primary schools on housing prices, the paper also investigated the heterogeneity that exists across various house sizes. The number of bedrooms has often been used to define housing types [38]. In this study, when computing the average housing prices, the sample was differentiated into two groups, that is, small houses (houses with only one or two bedrooms) and large houses (those with more than two bedrooms). For each residential complex, the average housing prices for small houses and large houses were then computed, respectively. Because some residential complexes may only have small houses and others only large houses, the final residential complex sample for small and large houses differed from each other. Nevertheless, the study re-estimated Equations (1) and (2) for the average price of small houses and average price of large houses, respectively, using the newly generated residential complex sample.

4. Results

4.1. Descriptive Statistics

The descriptive statistics of the dependent and independent variables are presented in Table 2. The resale price per square meter of complexes in the sample was about CNY 72,614 (approximately USD 10,300 in 2019) on average, ranging from CNY 40,563 to CNY 133,566. Moreover, there was an obvious gap between complexes within the attendance zone of a key primary school and those outside of the zone. For those within the attendance zone, the average price was about CNY 79,126, whereas those outside of the zone was only CNY 66,102 on average. By contrast, the difference in the monthly rents between complexes within and outside of the key schools' attendance zones was much smaller. The average monthly rents for the school district houses and the others were CNY 8884 and CNY 8230, respectively. Both values were quite close to the sample average, which was CNY 8358.

Table 2. Summary statistics.

Variables	Obs.	Mean	Std. Dev.	Min	Max	Mean for Treated	Mean for Control
Price	254	72,613.98	18,131.7	40,563.83	133,565.9	79,126.35	66,101.62
Rent	242	8357.99	5649.58	3366.67	44,966.67	8484.33	8229.54
School	254	0.50	0.50	0	1	1	0
Year	254	26.82	15.9	3	108	26.5	27.1
FAR	254	2.25	0.91	0.20	5.10	2.39	2.11
Green	254	0.36	0.11	0.04	0.70	0.36	0.35
Fee	254	1.63	1.41	0.20	10	1.78	1.48
D_subway	254	0.67	0.35	0.051	1.9	0.68	0.66
D_hospital	254	1.38	0.86	0.031	5.23	1.39	1.37
D_square	254	6.90	2.87	0.837	24.65	6.87	6.93
D_station	254	15.13	5.65	3.88	25.81	15.13	15.13
D_school	254	0.48	0.35	0.018	1.96	0.33	0.63

Note: Authors' own calculation. USD 100 is about CNY 705.33 according to the average exchange rate of the Bank of China from 1 January to 31 October 2019.

Because the study paired each school district complex with a neighboring complex outside of the key school's attendance zone, the sample consisted of half school district complexes and half non-school district complexes. The average building age of the sampling complexes was 26.8 years, while the oldest complex was 108 years old; the age of the newest complex was merely 3 years old. The floor area ratio of the sampled complexes, i.e., the ratio of construction area to land area, was 2.25 on average, ranging from 0.2 to 5.1. The green area rate of the sampled complexes ranged from 0.04 to 0.7, with a mean ratio of 0.36.

The mean management service fee of the sampling complexes was CNY 1.63 per month per square meter, while the maximum and minimum levels were CNY 0.20 and 10, respectively. The sampled complexes' average straight-line distances to the nearest subway

station and nearest hospital were 0.67 and 1.38 km, respectively; the distance between the sampled housing complexes and Renmin square, Hongqiao station, and the selected primary school were about 6.9 km, 15.13 km, and 0.48 km, respectively.

4.2. Results from Hedonic Price Model

Table 3 reports the results from the hedonic price model. High-quality education had a positive impact on housing prices. Specifically, high-quality education led to a more than CNY 10,000 (approximately USD 1460 in 2019) price premium, or 14.8%. By contrast, high-quality education did not significantly affect the rents of the housing complexes, which confirms that the price premium is attached to the high-quality education instead of other location characteristics. This is similar with the results observed in Beijing which was about CNY 2000 [13], although the estimated price premium in this study is much larger.

Table 3. Results of hedonic model.

Variables	***Price***	***ln Price***	***ln Price***	***Rent***	***ln Rent***	***ln Rent***
School	10,301 ***	0.148 ***	0.150 ***	−408.4	−0.0275	−0.0447
	(1676)	(0.0226)	(0.0240)	(472.7)	(0.0404)	(0.0398)
Year	−89.16	−0.00129	−0.000778	−36.88 **	−0.0080 ***	−0.0073 ***
	(77.00)	(0.00105)	(0.00099)	(15.97)	(0.00185)	(0.00149)
FAR	1641	0.0192	0.0291 *	28.66	0.0224	0.0267
	(1150)	(0.0149)	(0.0166)	(302.8)	(0.0276)	(0.0259)
Green	11,872	0.233 *	0.214	1753	0.522 **	0.511 **
	(9765)	(0.123)	(0.143)	(2447)	(0.228)	(0.215)
Fee	4420 ***	0.0576 ***	0.0703 ***	2975 ***	0.224 ***	0.234 ***
	(892.4)	(0.0118)	(0.0116)	(363.1)	(0.0256)	(0.0248)
D_subway	−5847 ***	−0.081 ***	−0.101 ***	92.61	−0.0827	−0.0979 *
	(1904)	(0.0283)	(0.0301)	(691.3)	(0.0574)	(0.0548)
D_hospital	−859.4	−0.00872	−0.00882	−228.8	−0.0299	−0.0375 *
	(1026)	(0.0146)	(0.0142)	(193.9)	(0.0209)	(0.0192)
D_square	−1614 ***	−0.024 ***	−0.024 ***	−1.300	−0.0173	−0.0167
	(547.4)	(0.00817)	(0.00650)	(107.8)	(0.0154)	(0.0123)
D_station	196.9	0.00112	0.00441 **	102.0	0.00156	−0.00690 **
	(408.2)	(0.00578)	(0.00194)	(115.6)	(0.0104)	(0.00325)
D_school	−2777	−0.0212	0.00119	789.4	0.0138	−0.0328
	(2544)	(0.0339)	(0.0332)	(1290)	(0.0712)	(0.0704)
District Dummies	Yes	Yes	No	Yes	Yes	No
Constant	54,939 ***	10.92 ***	11.03 ***	2339	8.666 ***	8.823 ***
	(12,221)	(0.171)	(0.116)	(3339)	(0.289)	(0.180)
Observations	254	254	254	242	242	242
R^2	0.602	0.613	0.512	0.699	0.734	0.725

Note: Robust standard errors in parentheses. *** Statistical significance at 1%. ** Statistical significance at 5%. * Statistical significance at 10%.

Some control variables also showed a significant impact on housing prices and rents. The age of the building reduced housing rents by approximately 0.8%. The management service fee had a positive impact on both housing prices and rents. An increase in the management service fee by one unit resulted in a 5.8% increase in prices and 22.4% increase in rents, respectively. Both the distance to the nearest subway station and distance to Renmin square had a more significant impact on the housing prices compared with the rents. As the distance from the residential complex to the nearest subway station increases by one kilometer, the houses resale prices dropped by approximately CNY 5847 (approxi-

mately USD 830 in 2019), or 8.1%. House resale prices would decrease by 2.4% with every increasing kilometer of distance from the commercial center of Renmin Square. Moreover, the main results are consistent, excluding the district fixed effect.

4.3. Results from Paired Difference Model

Table 4 reports the results from the paired difference model. Compared with the paired residential complexes outside of the key primary school admission zone, the average house resale prices of the residential complexes within the key primary school admission zone were higher by CNY 11,424 (approximately USD 1620 in 2019). This is consistent with the results in the hedonic price model. Furthermore, the impact of the differentials of control variables was statistically insignificant; the exception was the management service fee, which had a significant impact on both the average resale prices and rents of the housing complexes. Similar to the hedonic price model, the average rents for residential complexes within and outside of the key primary school admission zone did not show a significant difference. This further indicates that the price premium of school district houses is largely due to the education quality itself rather than other location factors.

Table 4. Results of paired difference model.

Variables	Δ *Price*	Δ *ln Price*	Δ *Rent*	Δ *ln Rent*
Δ*School*	11,424 ***	0.156 ***	−332.9	−0.0420
	(1842)	(0.0254)	(701.9)	(0.0497)
Δ*Year*	−73.44	−0.0018	−25.43	−0.00483 **
	(143.5)	(0.00220)	(22.39)	(0.00197)
Δ*FAR*	1930	0.0169	248.8	0.0195
	(1404)	(0.0171)	(389.9)	(0.0356)
Δ*Green*	2562	0.115	1785	0.290
	(11,645)	(0.159)	(3325)	(0.291)
Δ*Fee*	3200 ***	0.0369 **	1656 ***	0.145 ***
	(1181)	(0.0143)	(630.3)	(0.0410)
Δ*D_subway*	−230.7	-7.70×10^{-5}	949.9	−0.0465
	(4647)	(0.0705)	(1665)	(0.145)
Δ*D_hospital*	899.9	0.0123	357.8	0.0223
	(2032)	(0.0295)	(514.2)	(0.0416)
Δ*D_square*	−4702	−0.0653	926.6	0.0802
	(3677)	(0.0493)	(1230)	(0.102)
Δ*D_station*	−3074	−0.0438	298.0	0.0743
	(2876)	(0.0435)	(763.9)	(0.0676)
Δ*D_school*	860.9	−0.00716	−285.3	−0.160
	(4285)	(0.0579)	(1995)	(0.129)
Observations	127	127	121	121
R^2	0.157	0.156	0.288	0.376

Note: Robust standard errors in parentheses. District dummies are cancelled out in the paired difference model. *** Statistical significance at 1%. ** Statistical significance at 5%.

4.4. Heterogeneous Effects

Table 5 shows the heterogeneous effects of school quality premiums on housing prices across house sizes. For small houses (i.e., those with only one or two bedrooms), the price premium of high-quality education was about CNY 11,734/m^2 (about USD 1660 in 2019) and 16.8%. By contrast, the price premium for large houses (i.e., those with three or more bedrooms) was slightly lower, which was approximately CNY 10,004/m^2 (about USD 1420 in 2019) and 13.9%. The exclusion of regional dummies did not affect the robustness of the results.

Table 5. Heterogeneous effects for small and large houses (hedonic price model).

Variables	Small Size			Large Size		
	Price	***ln Price***	***ln Price***	***Price***	***ln Price***	***ln Price***
School	11,734 *** (1832)	0.168 *** (0.0244)	0.173 *** (0.0260)	10,004 *** (2187)	0.139 *** (0.0303)	0.130 *** (0.0304)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
District Dummies	Yes	Yes	No	Yes	Yes	No
Observations	236	236	236	100	100	100
R^2	0.607	0.621	0.520	0.629	0.610	0.570

Note: Robust standard errors in parentheses. *** Statistical significance level at 1%.

Table 6 shows the results from the paired difference model, which further confirms the results obtained from the hedonic price model. Specifically, for houses with more than two bedrooms, the premium of high-quality education was about CNY 9745/m^2 (about USD 1380 in 2019) and 12.7%. For houses with only one or two bedrooms, the price premium was approximately CNY 12,794/m^2 (about USD 1810 in 2019) and 17.3%. In general, a larger housing price premium from the high-quality education factor was observed in small houses, which was in line with the expectation.

Table 6. Heterogeneous effects for small and large houses (paired difference model).

Variables	Small Size		Large Size	
	Δ *Price* ^{s}	**Δ *ln Price*** ^{s}	**Δ *Price*** ^{l}	**Δ *ln Price*** ^{l}
Δ*School*	12,794 *** (1920)	0.173 *** (0.0259)	9745 *** (2920)	0.127 *** (0.0392)
Control Variables	Yes	Yes	Yes	Yes
Observations	118	118	50	50
R^2	0.155	0.152	0.527	0.518

Note: Robust standard errors in parentheses. District dummies are cancelled out in the paired difference model. *Price* ^{s} represents the housing price for small houses, while *Price* ^{l} refers to that for large houses. *** Statistical significance at 1%.

5. Discussion

This study estimated the housing price premium of high-quality primary schools in Shanghai, China. The results show that the estimated housing price premium of a key primary school is about CNY 11,424/m^2. On average, the price of houses associated with a high-quality primary school is 15.6% higher than that of houses associated with an ordinary primary school. This result is consistent with the study by Feng and Lu (2013), who found that an additional increase in the number of high-quality high schools per square kilometer increased the housing prices by approximately 17.1% in Shanghai [5]. Our study differs with this study by focusing on primary schools rather than high schools.

When it comes to primary school, the results are significantly larger than those obtained in the work by Zheng et al. (2016), though the results are almost identical to the findings by Zhang and Chen (2018) [9,13]. Using a similar approach, Zheng et al. (2016) found that in Beijing, the within-zone residential complexes had a price premium of CNY 2266/m^2 over those outside the attendance zone of a key primary school [13]. Several reasons could explain the difference. First, Zheng et al. (2016) obtained the data in 2011, whereas the data in this work were obtained in 2019 [13]. A significant increase in housing prices has been observed in recent years. Second, the definition of what a high-quality school is may affect the results. Zheng et al. (2016) defined a high-quality school based on historical information, whereas our definition was based on the newest school quality ranking [13]. Third, the competence for university enrollment in Beijing is not as high as that in Shanghai, making the role of high-quality primary schools less important in Beijing.

Zhang and Chen (2018) reported a similar price premium effect of key primary schools in Shanghai using a hedonic pricing model [9].

The results also show that a high-quality school has no effect on housing rent in Shanghai. This is in line with the findings obtained in Beijing [13], but conflicts with many studies conducted in other countries [39–41]. The difference in the impact of high-quality primary schools on housing rent between China and other countries is mainly due to the unique institution in Shanghai, that is, the unequal enrolment right for key primary schools between house owners and lessees. This unequal enrolment right policy may intensify the demand for school district houses and further enlarge the housing price premium of high-quality primary schools.

The housing premium of key primary schools is heterogeneous for small and large residential units. Specifically, the estimated premium of large residential houses was 12.7% (CNY 9745/m^2); by contrast, small residential houses had an estimate as high as 17.3% (CNY 12,794/m^2). These results are in opposition with the findings obtained in Florida, where large houses seemed to have a higher price premium from education [42]. Beracha and Hardin (2021) believe that large houses represent a family-oriented housing type and small houses are unsuitable for families [42]. However, in Shanghai, many families are living in houses with two or fewer bedrooms due to the high housing prices. When the policy design allows for a small-sized house ownership to also receive the equal enrolment right, a larger demand for small houses could lead to a higher price premium of high-quality primary schools.

6. Conclusions

Administrative school attendance zoning in China allows students to enjoy the benefit of enrolling in a nearby school. However, unequal school quality between different school attendance zones may intensify educational inequality and further affect housing prices. This study improved our understanding of the formation of housing prices by investigating whether high-quality primary schools may affect housing prices and the extent to which they do; the study used a residential complex sample from Shanghai, China. Applying the hedonic price model, a boundary fixed effect, and the paired difference model to house resale transaction data from January to October 2019, the study found the housing price premium of key primary schools to be around 15.6%. Moreover, the price premium of smaller houses was larger than that of larger houses. In addition, the study did not find a rent premium for houses associated with high-quality schools.

The results support the prediction of the Tiebout model. When public expenditures on education is unevenly distributed across space, people may compete for access to high-quality educational resources via residential sorting. The increase in demand for houses that is associated with high-quality educational resources leads to increases in housing prices, as long as there is little to no mobility barrier in the housing markets. In China, residence mobility across cities has often been restricted by the *Hukou* system. However, when it comes to residence mobility within a city, there is a limited institutional barrier, allowing for the presence of the Tiebout prediction.

The results show that the capitalization of education to housing price indeed exists under the housing-based school admission system in the studied area. However, the generalization of our findings to other contexts should be made with caution. First, the education admission system may differ between cities, which may induce heterogeneity in the price premium levels. Future studies may further test the results by focusing on other cities with different education admission policies. Second, the dynamic changes in policy environment and housing prices may have a moderating effect on the housing price premium of high-quality primary schools. This may restrict the generalization of the results over time. Thus, longitudinal data could be used in a future analysis.

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Appendix A

Table A1. Selected key primary schools in each district.

No.	Yangpu	Hongkou	Pudong	Changning
1	Kongjiangercun Primary School	Hongkou No. 4 Primary School	Mingzhu Primary School	Tianshan No. 1 Primary School
2	Dahushan Road No. 1 Primary School	Guangling Road Primary School	Fushan Foreign Language Primary School	Lvyuan Primary School
3	Primary School Affiliated with University of Shanghai for Science and Technology	Hongqi Primary School	Primary School Affiliated with Puming Normal School (Weifang)	Shanghai Jianqing Experimental Primary School
4	Yangpu Primary School	Quyang Road No. 4 Primary School	Jincai Experimental Primary School	Shicun Primary School
5	Qiqihaer Road No. 1 Primary School	Quyang Road No. 3 Primary School	Jianping Experimental Primary School (Zaozhuang)	Xingfu Primary School
6	Yongfeng Road Primary School	Shanghai No. 2 Normal School Primary School	Shanghai No. 6 Normal School Primary School (Yushan)	Shanghai Changning Experimental Primary School
7	Shanghai Conservatory of Music Experimental Primary School	Hongkou Experimental Primary School	Xinshijie Experimental Primary School	
8	Fudan Science Primary School	Changqing School	Haitong Primary School	
No.	**Putuo**	**Jingan**	**Xuhui**	**Huangpu**
1	Primary School Attached to East China Normal University	Shanghai No. 1 Normal School Primary School	Gaoan Road No. 1 Primary School	Penglai Road No. 2 Primary School
2	Wuning Road Primary School	Primary School Affiliated with Jingan Education College	Xiangyang Primary School	Cao Guangbiao Primary School

Table A1. *Cont.*

No.	Yangpu	Hongkou	Pudong	Changning
3	Jiangning Primary School	Wanhangdu Road Primary School	Huishi Primary School	Huangpu No. 1 Primary School
4	Zhenruwenying Primary School	Shanghai Jingan No. 3 Primary School	Jianxiang Primary School	Huangpu Foreign Language Primary School
5	New Putuo Primary School	Pengpuxincun No. 1 Primary School	Xuhui No. 1 Primary School	Huining Road No. 3 Primary School
6	Zhaochun Primary School	Jingan No. 1 Primary School	Dongan Road No. 2 Primary School	Fuxing East Road No. 3 Primary School
7	Zhongbei No. 1 Primary School	Zhabei No. 2 Primary School	Tianlin No. 3 Primary School	Jiangsu Road No. 5 Primary School
8	Zhongyuan Primary School	Daning International Primary School	Tianlin No. 4 Primary School	Shanghai Experimental Primary School
9	Jinyuan Primary School	Zhabei Primary School	Shanghai Primary School	Luwan No. 1 Primary School
10	Changzheng Primary School		Qiuzhi Primary School	Luwan No. 2 Primary School
11				Luwan Experimental Primary School Affiliated with Shanghai Normal University

Table A2. The price adjusting index according to the transaction time.

	Pudong	Xuhui	Jingan	Putuo	Yangpu	Hongkou	Changning	Huangpu
Jan	1.039220	1.021864	1.024398	1.026187	1.035856	1.023482	1.019099	1.056783
Feb	1.036422	1.020945	0.995334	1.043191	1.035546	1.013449	1.012718	1.062841
Mar	1.038083	1.009537	0.968978	1.033886	1.034718	1.013551	1.023568	1.032286
Apr	1.028925	0.991882	0.977187	1.031720	1.021641	1.014159	1.023159	1.019642
May	1.032539	0.990396	0.968374	1.019486	1.017368	1.018130	0.996357	1.006159
Jun	1.017581	0.993875	0.959832	1.003925	1.008093	1.017520	1.000559	1.002450
Jul	1.012619	1.005437	0.968158	0.997838	1.001185	1.005752	1.014355	1.008096
Aug	1.014953	0.994006	0.963917	1.003458	1.004601	1.012434	1.013341	0.999698
Sep	1.009	0.9987	0.978	0.995	1.0044	1.0041	1.0049	1.0012
Oct	1	1	1	1	1	1	1	1

Source: The data were obtained from the Soufang estate agency.

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