How School Admission Uncertainty Affects Residential Location Choice? Evidence From China's School Lottery

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Abstract

To relieve the strain on public school seats and mitigate competition for elite schools, Beijing introduced a school lottery that severed the link between housing and school assignments. Using housing transaction data from Beijing, we leverage the school lottery as a quasi-experiment to examine how school admission uncertainty affects parental decisions on residential location. Our findings show that, while the school lottery reduced the school-quality premiums of school district houses (SDHs), especially tier 1 SDHs, its impact on tier 2 SDHs was negligible. Besides, the lottery had heterogeneous effects in different school zonings. In zonings with less admission uncertainty, premiums for SDHs either increased or remained unaffected. These indicate that households, in response to admission uncertainty introduced by the lottery, tended to opt for SDHs with higher admission probabilities. This new pattern of school and residential location choice limited the policy's effectiveness, which was an unintended consequence from policymaker's perspective.

Keywords: Residential location choice, School lottery, School choice, School admission uncertainty, Residence-based enrollment

1 Introduction

Public school choice is an integral part of residential location choice, regardless of whether the school enrollment system offers multiple school choices or not. A large literature documents the relation between school choice and residential location choice. These papers advance our understanding of how household's residential location choice interacts with school choice. A strand of them develops theoretical models incorporating endogenous residential decision to examine how school choice affects residential location choice (Avery and Pathak, 2021; Bayer et al., 2007; Ferreyra, 2007; Park and Hahm, 2023). Another strand provides empirical evidence on residential location choice in response to school enrollment policies, including open enrollment (Brunner et al., 2012; Ely and Teske, 2015), school choice lottery

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(Bibler and Billings, 2020), and school desegregation (Baum-Snow and Lutz, 2011). However, because most of these studies primarily concentrate on school choice with multiple options, how households choose residential locations under residence-based enrollment coupled with uncertainty in admission is underexplored.

This paper provides novel evidence of how school admission uncertainty affects households' residential location choices in the context of a residence-based enrollment system. Using housing transaction data from Beijing, we estimate the parental valuation on the probability of their children's enrollment in public elementary schools following a school lottery policy. Specifically, we leverage the school lottery policy as a quasi-experiment and employ difference-in-differences to estimate the policy effect on the school-quality premiums of school district houses (SDHs, henceforth). The policy was designed to alleviate the strain on public school seats and break the ties between housing and schools assignment, which introduces uncertainty to the admission process. Besides, we also build a theoretical model of residential location choice incorporating school choice, which helps to illustrate households' choices under uncertainty.

Our findings show that, while the school lottery reduced the school-quality premiums of SDHs, especially tier 1 SDHs, its impact on tier 2 SDHs was negligible. Besides, the lottery had heterogeneous effects in different school zonings. In zonings with less admission uncertainty, premiums for SDHs either increased or remained unaffected. These indicate that households, in response to admission uncertainty introduced by the lottery, tended to opt for SDHs with higher admission probabilities. This new pattern of school and residential location choice restricted the policy's effectiveness, which was an unintended consequence from policymaker's perspective.

Previous studies largely focus on the school choices with multiple options in developed countries, which are not fully applicable to developing countries. This is because residence-based enrollment, an one-to-one assignment pattern, is the prevalent K-12 enrollment system in developing countries (Snyder et al., 2019). This pattern in developing countries leads to the equivalence of school choice to residential location choice for households seeking quality education. While the effect of uncertainty on school choice in developing countries is inconclusive, papers in the context of multiple school choices would poorly shed light on our question.

Moreover, prior papers on China's residence-based enrollment focused on the capitalization effect of school quality on housing prices (Chan et al., 2020; Feng and Lu, 2013; Han et al., 2021b; Zheng et al., 2016). Few of them explored parental choice on school in response to enrollment reform. Han et al. (2021a) estimated the policy effect of restricting access to senior high schools on housing prices, but they did not take into account household's school or residential location choice. Our study fills this gap by providing evidence on household's school and residential location choice from China's residence-based enrollment.

The most relevant enrollment system to our paper is the school lottery, which introduces uncertainty to the admission process. A school lottery system is a random selection process used to determine which students will attend, and it is implemented when there are more students applying for admission than can be accommodated. There are several papers on how school lottery impacts households' residential location and school choice. Andreyeva and Patrick (2017) and Bonilla-Mejía et al. (2020) took into account the school admission uncertainty in admission probability. However, as we mentioned above, their settings were based on school choice with multiple options instead of the traditional residence-based admission, limiting their application in developing countries.[1]

A growing literature investigated the policy effect of school lottery in China. Jin et al. (2023) and Chen and Li (2023) both examined parental school choice between public elite schools and private elite schools in response to uncertainty in private schools' lottery enrollment. However, public school enrollment was not subject to the lottery in their studies and most households' school choices within public schools were not affected by uncertainty. Huang et al. (2020) and Lei et al. (2023) examined the school lottery policy in Beijing, which is the same policy studied in this paper . While they mainly estimated the effect on the premium of school district house and whether the policy contributed to education equality, they did not discuss anything related to school and residential location choice. Compared to their work, we focus on the effect of uncertainty introduced by the lottery on parental choice of school and residential location and evaluate the policy's effectiveness through this perspective.

This paper provides new evidence on the effect of uncertainty on household's decision-making on school and residential choice, particularly when options available are limited. Besides, we fill the gap of few empirical evidence on how school admission uncertainty influences residential location choice under residence-based enrollment, particularly in the context of China's public school enrollment system. Our findings also have policy implications for developing countries facing the dilemma of insufficient public school seats coupled with intensive competition for elite schools through residential location choice.

The rest of the paper is structured as follows. Section 2 describes the background of school choice in China and the school lottery policy. Section 3 presents data source and some important definitions. Section 4 is the theoretical analysis. Section 5 is the empirical analysis. Section 6 concludes.

[1] Andreyeva and Patrick (2017) and Bonilla-Mejía et al. (2020) leveraged school choice lottery's admission priority in the settings of school choice lottery and charter school, respectively.

2 Background

2.1 School choice in China

China's location-based assignment system shapes Chinese households' school choices. Since the implementation of "nearby enrollment policy", a one-to-one link between houses in each community and public schools was founded. Specifically, public schools designate an enrollment area known as *school district*,[2] and housing ownership is a necessity for children to attend the nearby school. The strict housing ownership requirement limits household's school choices, but creates a market with parental demand for good schools through residential choice. School district house (henceforth, SDH), located in the school district of an elite elementary school, accordingly becomes a favored educational investment for families.

However, irrational rise in SDH premiums has made quality public education increasingly unaffordable (Zheng et al., 2016). In many major cities, the school choice competition drove the prices of SDHs to new records, with the value of SDHs being more of an investment for speculation. "School district housing fever" has become a social phenomenon, especially in metropolitan areas like Beijing.[3] School-quality premiums of SDHs in Beijing kept rising for a long time (see Figure 1). According to estimates by Han et al. (2021b), the school-quality premiums for elite elementary schools in Beijing rose from 8.4% to 12.3% during 2013-2016, equivalent to the price of SDHs rising from 3,693 yuan per square meter to 5,649 yuan per square meter. This induced the policymakers to curb the rising trend of SDH premium.

Moreover, the strain of educational resources in megacities posed another challenge. Beijing, one of the most densely populated cities in China, witnesses a burgeoning population of more than 20 million, which put a strain on public resources, particularly on the access to elementary schools. According to 2, the total number of elementary school in Beijing kept decreasing, while the number of elementary school enrollments (the sum of Beijing and non-Beijing enrollments in the figure) was increasing. This imposed great pressure on the seats schools could provide and turned elite schools increasingly oversubscribed. In addition, the introduction of the "two-child policy" in 2014 would significantly increase new students and further overwhelm the school capacity in the near future. It was imperative for policymakers to figure out a solution to the dilemma.

2.2 The school lottery in Beijing

Given the two problems above, the Beijing Municipal Education Commission introduced the "multi-school zoning policy". It integrates several adjacent school districts into a school zoning and assigns students within the zoning. Its assignment rule features a random lot-

[2] It is similar to the school catchment area in the US.

[3] "Why Anxious Parents Are Driving a Home Price Surge in China" - Bloomberg (2021)

tery, thus called as school lottery. It was adopted in April 2018 for Dongcheng and Haidian, and in April 2020 for Xicheng (the three districts are called "DHX" henceforth). The policy stated that housings purchased after the implementation time would be subject to the school lottery and be randomly assigned within the school zoning as long as the nearby school was oversubscribed. By severing the link between houses in each community and their nearby schools, the policy created the uncertainty of school assignment, which was meant to reduce the SDH premiums and alleviate the strains on school seat in elite schools.

The enrollment regulation of the school lottery can be illustrated by 3. The largest grey area in the figure represents the school zoning (henceforth, zoning) that are made up of four school districts denoted by the small grey areas. The school lottery works within every single zoning respectively. There are four schools in the zoning, with School A and B elite schools, School C and D non-elite schools. Besides, students are originally assigned to the school tied to their communities within the same school district. We assume that School A and School C are oversubscribed,[4] and new students from Community 1 and Community 2 would be assigned to another school in the zoning. According to the school lottery, new students from Community 1 would be assigned to School B with priority, while those from Community 2 would be assigned to School D without other choice. This pattern implies that the school lottery was not designed to equalize access to elite schools. Instead, SDHs maintain an advantage due to their priorities of being assigned to another elite school, while non-SDHs remain tied with non-elite schools.

3 Data and definitions

3.1 Data source

This study utilizes Beijing's residential housing transactions from Lianjia, Beijing's largest real estate agent. The data is primarily sourced from transactions in four major districts of the city: Dongcheng, Xicheng, Haidian, and Chaoyang, covering the period from January 2016 to January 2021. Every housing transaction of the dataset includes details such as transaction time, transaction price, property characteristics (e.g., area, layout, floor, elevator, year of construction, latitude and longitude coordinates), and neighborhood characteristics (e.g., greening rate, property fee, distance to Tiananmen) for each property transaction. The dataset comprises a total of 131,504 transactions spanning 3,612 neighborhoods within the four city districts.

To show the representativeness of our data, we compare two key indicators—transaction volume and house price growth rate—derived from our dataset with the corresponding official statistics. In Figure 6, we compare the annual transaction volume in our sample data

[4]Oversubscribed schools are those facing the dilemma of the number of applicants exceed the enrollment plan.

with the officially published second-hand house transaction volume in the Beijing Real Estate Yearbook for the period 2017-2020. Notably, the sample volume of transaction data provided by Lianjia constitutes more than half of the official transaction volume. In Figure 7, we compare the monthly year-on-year house price growth rates in Beijing, calculated from both the sample data and official statistics. The curve of our sample generally aligns well with the official curves. Taken together, the sample data used in this paper is shown to be representative of Beijing's second-hand property market during the sample period.

3.2 Designation of the SDH in this paper

Before the commencement of each school year, elementary schools release their enrollment prospectus to the community, outlining the school's catchment area, referred to as the school district in this paper. We collected the annual enrollment prospectus of each elementary school in the four districts of the city. Subsequently, we matched all transaction properties in our dataset with their corresponding elementary school based on the transaction date and the enrollment prospectus of the same year.

In order to explore the heterogeneous treatment effects of school lottery on the housing prices of SDH, we divide the SDH into three categories:

- **Tier 1 SDH (S1):** Housing is located within the school district of tier 1 elite elementary schools. Tier 1 elite schools refer to the top 5 schools within the district.
- **Tier 2 SDH (S2):** Housing is located within the school district of tier 2 elite elementary schools. Tier 2 elite schools refer to the top 6-20 schools within the district.
- **Other SDH (S3):** Housing is located within the school district of quasi-elite elementary schools. Quasi-elite elementary schools include branch schools that are associated to the elite schools.
- **Non-SDH (S4):** Housing is located within the school district of non-elite elementary schools.

The ranking of elementary schools used in this paper is based on a commonly accepted ranking of reputation among Beijing's local residents, also widely used in the literature (Han et al., 2021b; Huang et al., 2020; Zheng et al., 2016).

Table 1 presents descriptive statistics of various types of SDH in the three districts of DHX, respectively. The housing prices show that non-SDH are notably cheaper than SDH. The difference in housing prices among various types of SDH is even greater. Particularly, the housing prices between tier 1 SDH and non-SDH differ by about 40,000 per square meter, reflecting a high degree of education premium in housing prices. Comparing variables related to living conditions, such as area, furnishing conditions, elevator, age, and greenery rate, non-SDHs have better living conditions. In contrast, living conditions for tier 1 and tier 2 SDH are very similar, with many being old and small. In terms of the sample size, SDHs account for about 45% of the whole sample, while tier 1 SDHs constitute only about 6%. This highlights the scarcity of high-quality education resources in Beijing.

In this paper, we introduce a new concept called "school zoning" (zoning, henceforth), representing a large school enrollment area. A zoning is formed by several school districts and is bounded by main arteries (see Figure 3 for illustration). Educational officials in Beijing designate these zonings for better regulation. Moreover, we categorize zonings into two groups: dense zonings and other zonings (see Figure 4 and Figure 5). Dense zonings are characterized by elite elementary schools (tier 1 elite schools, tier 2 elite schools, and quasi-elite schools) constituting more than 60% of all elementary schools within the zoning. The choice of the 60% threshold is not arbitrary; instead, it is derived by consulting professional property agents. To eliminate the possibility that our results are derived by design, we replace 60% with 50% and 70% in the robustness tests to validate our results.

4 Theoretical analysis: A model of school choice

We model households' school choice in the context of purchasing SDHs for their children's enrollment in an elite school. It features households' utilities for housing characteristics, school qualities, and housing costs. We employ the model to illustrate households' decisions of school choice under the school lottery, in which households also take into account the admission probability.[5]

4.1 Model setup

Definition 1 (School quality). There are four types of schools for households to choose: tier 1 elite schools, tier 2 elite schools, quasi-elite schools, and non-elite schools, represented by s_1, s_2, s_3, s_4, respectively. And we set the school quality of s_1 relative to that of s_4 as y_1, thus y_2 for s_2, and y_3 for s_3. The school-quality ranking is $y_1 > y_2 > y_3$.

Definition 2 (Housing prices). The housing price, p, for SDHs are ranked based on the school quality. And we set the school-quality premium of tier 1 SDH as p_1, equivalent to the relative price compared to that of non-SDH. Thus, the premium for tier 2 SDH is p_2, and the premium for other SDH is p_3. The price ranking is $p_1 > p_2 > p_3$.

Following the utility function specification in Bayer et al. (2007), we model households' school choice in the form of residential location decision. Let X_h represent the observable characteristics of housing choice h, including housing and community characteristics (e.g., size, age, floor, and plant area). Let p_h denote the price of housing choice h. Again, y_j^h repre-

[5]A reminder is that the model was designed to illustrate the school choice but not to simulate it, as we leave the examination work for the empirical analysis. Therefore, the parameters of the model are not estimated.

sents the quality of school j that is originally tied to the housing h. Each household chooses its residence h to maximize its indirect utility function $V_i(h, j)$.

Household i's utility from housing choice h and attending school j is

$$V_i(h, j) = \alpha_i^X X_h + \underbrace{\alpha_i^y y_j^h}_{\text{utility from school j}} - \underbrace{\alpha_i^p p_j^h}_{\text{housing cost of } h} + \xi_h + \epsilon_i$$

The error term ξ_h captures the unobserved amenities of housing choice h, and ϵ_i is idiosyncratic preferences shocks over locations and schools.

4.2 School lottery

Next, we consider the scenario under the school lottery that breaks the ties of housings with their originally assigned schools. And the new element added to the model is uncertainty, measured by the probability of admission to the originally assigned school.

Assumption (Admission probability). Due to the shortage of quality educational resources, s_1 is the fewest and also the most sought-after, followed by s_2, and so on. The admission probabilities for these schools are set to be γ_1 for s_1, γ_2 for s_2, γ_3 for s_3, and γ_4 for s_4. And we assume that the ranking of the admission probabilities is $\gamma_1 < \gamma_2 < \gamma_3 < \gamma_4$.

Under the school lottery, household i's expected utility from housing choice a, a tier 1 SDH, would be

$$E[V_i(a, \underbrace{\hat{s}_1}_{\text{not for sure}})] = \alpha_i^X X_a + \gamma_1 \alpha_i^y y_1^a + \underbrace{\gamma_2 \alpha_i^y y_2^a + \gamma_3 \alpha_i^y y_3^a}_{\text{assigned to other school}} - \alpha_i^p p_1^a + \xi_a + \epsilon_i$$

Household i's expected utility from housing choice b, a tier 2 SDH, would be

$$E[V_i(b, \underbrace{\hat{s}_2}_{\text{not for sure}})] = \alpha_i^X X_b + \gamma_2 \alpha_i^y y_2^b + \underbrace{\gamma_3 \alpha_i^y y_3^b}_{\text{assigned to other school}} - \alpha_i^p p_2^b + \xi_b + \epsilon_i$$

Conclusion 1. Comparing housing choices a and b, achieving maximum utility depends on the trade-off between the additional costing of s_1 compared to s_2 and the expected utility from the school-quality of s_1. If s_1 compared to s_2 is overvalued for the expected utility from the school-quality of s_1, i and other households will prefer housing choice b until p_1 decreases to normal. The residential sorting in tier 1 and tier 2 SDHs awaits further empirical evidence.

4.3 Dense zoning

Furthermore, we consider the scenario of school choice within the dense zoning. Dense zoning features more elite schools and provides more seats for elite schools, which implies that the admission probabilities in dense zonings are higher than those in other zonings. Therefore, we add the condition of $\gamma_j^D > \gamma_j^O$, where γ_j^D denotes the admission probability of school j in dense zonings and γ_j^O denotes that in other zonings.

Household i's expected utility from housing choice c , a tier 1 SDH in the dense zoning, would be

$$\underbrace{E[V_i^D(c,\hat{s}_1)]}_{\text{in the dense zoning}} = \alpha_i^X X_c + \gamma_1^D \alpha_i^y y_1^c + \gamma_2^D \alpha_i^y y_2^c + \gamma_3^D \alpha_i^y y_3^c - \alpha_i^p p_1^c + \xi_c + \epsilon_i > \underbrace{E[V_i^O(a,\hat{s}_1)]}_{\text{in other zonings}}$$

Household i's expected utility from housing choice d, a tier 2 SDH in the dense zoning, would be

$$\underbrace{E[V_i^D(d,\hat{s}_2)]}_{\text{in the dense zoning}} = \alpha_i^X X_d + \gamma_2^D \alpha_i^y y_2^d + \gamma_3^D \alpha_i^y y_3^d - \alpha_i^p p_2^d + \xi_d + \epsilon_i > \underbrace{E[V_i^O(b,\hat{s}_2)]}_{\text{in other zonings}}$$

Conclusion 2. Based on the comparisons of expected utilities above, we can make a plausible prediction that the advantages of higher admission probability in dense zonings would intensify residential sorting behaviors for SDHs within those dense zonings. We will provide empirical evidence to validate this prediction in the following section.

5 Empirical analysis

5.1 Empirical strategy

Before examining the impact of school lottery on the school-quality premium, we need to measure the school-quality premium of for each type of SDH. The school-quality premium of SDH is equivalent to the capitalization of school quality in housing prices, measured by the housing price increment of SDH relative to non-SDH. Specifically, we adopt the boundary fixed effect to compare a SDH with a non-SDH with the same amenities but within different school districts. This method eliminates the biases from unobserved amenities of housings (Bayer et al., 2007; Black, 1999). We control for the boundary fixed effect by matching every SDH with its nearest non-SDH within the distance of 500 meters. Meanwhile, we add covariates of housing characteristics and community characteristics to increase the precision of our estimates. These covariates are all outlined in the descriptive statistics (see Table 1).

The school-quality premiums are measured using the hedonic pricing model as follows:

$$\ln P_{it} = \alpha_0 + \beta_1 S_{it} + \sum_{n=1}^{N} \text{match}_n + \delta_t + \alpha_1 \text{X} + \epsilon_{it} \tag{1}$$

where $\ln P_{it}$ is ln(housing price). S_{it} is a dummy variable for the SDH, whose coefficient β_1 measures the school-quality premium of SDH. $\sum_{n=1}^{N} \text{match}_n$ is the boundary fixed effects which match SDHs with their nearest non-SDH within the distance of 500 meters. δ_t is the year-month fixed effect. X is a vector of housing characteristics and community characteristics. ϵ_{it} is an error term, clustered by every community.

Next, we use the school lottery as a quasi-experiment and leverage difference-in-differences to identify the policy effect on housing prices, with SDH as the treatment group and non-SDH as the control group (see Table 2). In the model, we also control for the boundary fixed effect and the same covariates as those in Equation 1. Additionally, we account for the specific time trend of every zoning to exclude the impact of zonings' unobserved factors on housing prices. We estimate the average treatment effects of school lottery using the following linear regression:

$$\ln P_{it} = \alpha_0 + \beta_0 \text{ Policy }_{it} + \beta_1 S_{it} + \sum_{n=1}^{N} \text{match}_n + \delta_t + \alpha_1 \text{X} + \text{t} \cdot \delta_i + \epsilon_{it} \tag{2}$$

where $Policy_{it}$ is a dummy variable for whether the housing i is a SDH and the transaction date is after the policy. β_0 captures the policy's treatment effect on school-quality premium of SDH. $\sum_{n=1}^{N} \text{match}_n$ is the boundary fixed effects which match SDHs with their nearest non-SDH within the distance of 500 meters. δ_t is the year-month fixed effect which absorbs the dummy for transaction date being after policy. X is a vector of housing characteristics and community characteristics. $t \cdot \delta_i$ is the specific time trend of every zoning where i is located. ϵ_{it} is an error term, clustered by every community.

It is worth noting that the school lottery is implemented at different timing in DHX (see Table 2). Difference-in-differences with variation in treatment timing may pose a threat to the robustness of the result due to heterogeneous treatment effects (de Chaisemartin and D'Haultfœuille, 2020; Goodman-Bacon, 2021; Sun and Abraham, 2021). In the subsequent robustness test, we validate our DID estimation results by using two alternative robust DID models.

To estimate the dynamic effects and test the parallel trend assumption, we use the event-study as follows:

$$\ln P_{it} = \alpha_0 + \sum_{k \geq -m}^{M} \beta_0 I_{it}(t = \tau_i + k) + \beta_1 S_{it} + \sum_{n=1}^{N} match_n + \delta_t + \alpha_1 \text{X} + \text{t} \cdot \delta_i + \epsilon_{it} \tag{3}$$

where $I_{it}(t = \tau_i + k)$ refers to the k_{th} month after school lottery is implemented.

5.2 Empirical results

5.2.1 School-quality premiums of SDHs

Table 2 reports the results of school-quality premium in housing prices before the school lottery was announced. Columns (1), (3), and (5) show the results of the overall school-quality premiums of elite schools, while columns (2), (4), and (6) show the results of the school-quality premiums for three types of elite schools. Additionally, columns (1) and (2) do not control for the boundary fixed effects. Columns (3) and (4) control for the boundary fixed effects but do not restrict the matching distance between SDHs and their nearest non-SDHs, while columns (5) and (6) control for the boundary fixed effects and restrict the maximum matching distance to 500 meters. As we control for the boundary fixed effects and restrict matching distance to 500 meters, school quality premiums gradually decline, suggesting that school quality premiums would be overestimated without appropriately controlling for the boundary fixed effects (Black, 1999).

After restricting matching distance to 500 meters, the overall school-quality premium is shown to be 7.7% in column (5), while the premium of tier 1, tier 2, and quasi-elite schools are 16%, 7.85% and 5.3%, respectively in column (6). The premiums imply that SDHs are generally 7.7% more expensive that non-SDHs, with the the price gap reaching 16% for tier 1 SDHs compared to non-SDHs. The notable variation in the school-quality premiums of different SDHs show the disparity of school-quality among different schools and highlight educational resource inequality in Beijing's major districts. Besides, the school-quality premiums we estimated above are comparable to those found in the literature within the context of Beijing (Chan et al., 2020; Chen and Li, 2023; Han et al., 2021b; Huang et al., 2020; Zheng et al., 2016), giving credit to our results. Taken together, the divergent premiums support the rationale for implementing the school lottery as a means to alleviate the educational disparities.

5.2.2 Policy impacts on school-quality premiums

Panel A in Table 4 reports the baseline results of impact of school lottery on school-quality premiums of SDHs. Column (1) displays the impact on the SDH premiums, including samples of all SDHs and non-SDHs. Columns (2) and (3) depict the impact on the premiums of tier 1 and tier 2 SDHs, respectively, with samples comprising tier 1 or tier 2 SDHs and non-SDHs.

We found that the school lottery decreased the SDH premiums by 1.18 percentage points (p-value < 0.05), which is equivalent to a 15% decrease of the overall premium of SDH. The most obvious policy effect is on tier 1 SDHs, with their premiums significantly falling by 5.31 percentage points (p-value < 0.01), equivalent to a surprising 33% reduction in the total premium. In contrast, the policy almost had no effect on tier 2 SDHs, with an insignificant negative effect of 0.32 percentage points on the premiums. Combining the results above, the school lottery managed to decrease the school-quality premiums of SDHs, which is mainly driven by the decline in the premiums of tier 1 SDHs.

To validate the different patterns in Table 4 between tier 1 SDHs and tier 2 SDHs, we divide the SDHs in our sample into 10 deciles based on their average housing prices and run the same regressions as those in Table 4. Figure 8 depicts the heterogeneous policy effects in different housing price deciles. Overall, the policy effect decreases and turns negative as the average housing price increases. According to the descriptive statistics in Table 1, the average housing prices of tier 1 SDHs are 121,890 yuan per square meter, while those of tier 2 SDHs are 102,901. Matching the deciles with the two kinds of SDHs by their prices, the pattern in the figure is shown to be consistent with that in the Table 4.

Taken together, the school lottery reduced the overall premiums of SDHs. While the premiums of tier 2 SDHs remained unaffected, the policy predominantly decreased the premiums of tier 1 SDHs. Additionally, the empirical results answer the question posed in our theoretical model. Households chose tier 2 SDHs over tier 1 SDHs under the school lottery because the housing cost of tier 1 SDH outweighed the expected utility from attending a tier 1 school. The results indicate that school admission uncertainty introduced by the lottery drove households to purchase tier 2 SDHs with less admission uncertainty.

5.2.3 Heterogeneous impacts in zonings

As we mentioned in subsection 3.2, zonings are comprised by several school districts and elite schools distribute unevenly in zonings, giving rise to the dense zonings where elite schools account for at least 60% of all elementary schools. Under the school lottery, students may be assigned to other schools within the zonings when their originally designated school is oversubscribed. This setting might benefit the dense zonings because SDHs in dense zonings are less likely to be assigned to a non-elite school compared to zonings with fewer elite schools. To test this hypothesis, we examine the policy impacts on the school-quality premiums of SDHs in the dense zonings and other zonings, respectively. Panel A of Table 5 presents the results of policy effects on the premiums of tier 1 and tier 2 SDHs in the dense zonings, while panel B shows those in other zonings.

We found that the premiums of tier 1 SDHs in the dense zonings are almost not affected by the policy, while the premiums of tier 2 SDHs in the dense zonings are significantly improved by 1.71 percentage points (p-value < 0.01). In contrast, the premiums of tier 1 SDHs in other zonings are significantly reduced by 5.27 percentage points (p-value < 0.01), while the premiums of tier 2 SDHs are barely affected. This disparity is further bolstered by the results in panel C, where we estimate the differences of policy effects between tier 1 and tier 2 SDHs using DDD models. Panel C shows the policy significantly improved the SDH premiums in the dense zonings compared to those in other zonings. This pattern supports our previous hypothesis that the SDH premiums in the dense zonings are benefited by the school lottery due to less risks of being assigned to a non-elite school.

Furthermore, the disparity between the policy effects on tier 1 and tier 2 SDHs aligns with the finding in the baseline results. Column (3) shows that the premiums of tier 1 SDHs decreased compared to that of tier 2 SDHs, whether in dense zonings or other zonings.

Overall, the SDH premiums in dense zonings relatively increased compared to those in other zonings. This indicates that households would choose SDHs located in an area with less admission uncertainty in response to the lottery's uncertainty. The results above support the prediction proposed in our theoretical model that the advantage of higher admission probability in dense zonings would lead to residential sorting between dense zonings and other zonings. Moreover, the residential pattern induced by households' risk-averse reactions limited the policy's effectiveness, which was an unintended consequence. It was unexpected for policymakers that the lottery would have divergent effects in different zonings. This implies that policymaking needs to anticipate the potential responses of those who will be affected.

5.2.4 Policy's dynamic impacts

We then examine the school lottery's dynamic impacts on school-quality premiums of SDHs using the event-study method based on the unit of month. Figure 9 depicts the dynamic effects on the premiums of all SDHs before and after the month the school lottery was announced.

We found that the pre-treatment trend is centered around zero, which means that the SDH premiums were stable before the policy was announced. This finding validates the parallel trend assumption required for DID.

Moreover, the premiums continued to decrease until the 27th month after the policy. This implies that the school lottery managed to reduce the overall premiums of SDHs for a relatively long time, bringing them towards a reasonable level.

5.3 Robustness check

5.3.1 Placebo test

During our sample period, three districts (DHX) of the four major districts in Beijing implemented the school lottery except for Chaoyang. We next use housing samples in Chaoyang to conduct a placebo test to examine the robustness of our results.

First, we need to ensure that Chaoyang is comparable to the other three districts. Table A1 shows the comparison of several key indexes ranging from economic development to education resource, indicating that Chaoyang is similar to the other three districts in these aspects. Second, no spillover effect from the other three districts is another important prerequisite. This means that the school lottery did not impact the housing transaction of SDH in Chaoyang. Figure A1 depicts the monthly transaction volume of SDH in Chaoyang. After the school lottery took effect in Xicheng, we did not see any sudden increase of transaction volume that was supposed to happen if spillover existed. This is because Chaoyang's SDH would be an alternative option for households seeking to avoid uncertainties. Taken together, the evidence above justifies the rationale of using Chaoyang for a placebo test.

We conducted the placebo test similar to the regressions of the baseline results in Table 4 using Chaoyang's SDHs as the treatment group and non-SDH as the control group. Panel A of Table 6 shows the results when setting the policy timing to be the same as Dongcheng and Haidian, which is April 2018. Panel B shows the results of policy timing same as Xicheng, which is April 2020. Results in both panels indicate that the SDH premiums increased after the simulated timing, which is quite opposite to the pattern in DXH. This reveals the counterfactual scenario in which the premiums of the SDHs in DHX would have continued to rise without the school lottery.

5.3.2 Event-study with robust DID models

As we mentioned earlier, the policy timing vary in our sample (see Table 2). This reminds us a caveat that the DID estimation could be compromised by the variation in with treatment timing (Callaway and Sant'Anna, 2020; de Chaisemartin and D'Haultfœuille, 2020; Sun and Abraham, 2021). We use two alternative robust DID models proposed by Callaway and Sant'Anna (2020) and Sun and Abraham (2021) and employ them along with our standard DID model in the event-study.

Figure 10 presents the comparison of three models. The robust DID models are marked by red and blue, respectively, while the standard DID model is in black. Three models' trends are almost parallel to each other, suggesting that our estimations using standard DID are robust even with various treatment timing.

5.3.3 Using SDHs as the alternative control group

One crucial assumption for DID estimation is that the control group is not affected by the intervention, and there is no spillover effect from the treatment group to the control group. Given that our DID estimations use the non-SDHs in DHX as the control group, the school lottery may affect the housing prices of non-SDHs.

To examine whether there was a direct policy effect on non-SDHs, we compare the time trends of average housing prices between non-SDHs and SDHs. Figure A2 shows that while housing price generally fluctuated less for non-SDHs compared to SDHs, there was a notable surge in housing prices around the second timing of policy adoption for non-SDHs, similar to what was observed in all SDHs. Besides, even though we can eliminate the direct policy effect on non-SDHs, we can not exclude the possible spillover effects from SDHs. Therefore, it is important to test the robustness of our results using the alternative control group.

As we argued in the placebo test, Chaoyang was immune to the school lottery and also the spillover effect from DHX, which made it an ideal for our alternative control group. We conduct new estimation using DHX's SDHs as the treatment group and Chaoyang's SDHs as the control group. It is worth noting that Chaoyang and DHX are spatially seperated, thus, invalidating the use of boundary fixed effect.

Table 7 shows the results of our new estimation using Chaoyang's SDHs as the control group, which aligns with our baseline results in Table 4. This bolsters the robustness of our DID estimations using DHX's non-SDHs as the control group.

5.3.4 Changing the baseline proportion of elite schools in the dense zonings

We next relax the restriction of setting the proportion of elite schools at 60% in the dense zonings. In order to test the robustness of the baseline proportion, we simulate two scenarios by increasing it to 70% and also decreasing it to 50%.

Figure A3 compares the results of three sets of proportions in the dense zonings and other zonings. Across three panels in the dense zonings, the premiums of tier 1 SDHs all insignificantly decreased after the school lottery, while the premiums of tier 2 SDHs increased after the policy. In contrast, the premiums of tier 1 SDHs significantly decreased for all three sets of proportions, while those of tier 2 SDHs were almost unaffected by the policy for all three sets of proportions. This pattern suggests that our results are robust to different proportions of elite schools in the dense zonings.

5.3.5 Impact of the covid-19 pandemic

After the covid-19 pandemic broke out in early 2020, lockdown in Beijing suspended the housing market from late January to mid-March. Even though the lockdown was canceled afterwards, the threat posed by the pandemic was still present. Thus, the long-lasting uncertainties caused by the pandemic may have discouraged or postponed household's willingness to purchase housings, especially SDHs considering the substantial costs associated with SDHs. This mechanism could challenge our results.

To exclude this possibility, we calculated the year-over-year growth rates of housing transaction for SDHs and non-SDHs in 2020. Figure A4 shows that all major districts' housing transaction in Beijing were back to normal after April in 2020, with the growth rate nearly remaining above zero for the rest of the year. This implies that the negative impact of the pandemic on the housing market was only a short-term suspension rather than a long-lasting recession.

6 Conclusion

Using a large micro dataset on residential housing transaction from Beijing, this paper examines how school admission uncertainty affects parental choice of residential location. We leverage the school lottery policy as a quasi-experiment and employ difference-in-differences to estimate the policy effect on school-quality premiums of school district houses (SDHs). We find that the lottery reduced the overall premiums of SDH by 1.18 percentage points. While the policy significantly decreased the premiums of tier 1 SDHs by 5.31 percentage points, the premiums of tier 2 SDH almost remained unchanged. The school lottery also had heterogeneous effects on the premiums of SDH in different school zonings. While the premiums of tier 1 SDHs in dense zonings were unaffected by the lottery, those of tier 2 SDHs in dense zonings were significantly improved. In contrast, the pattern shown in other zonings were completely different.

The results indicate that while the school lottery reduced the premiums of SDHs especially tier 1 SDHs, it had negligible effects on tier 2 SDHs. The lottery also had heterogeneous effects on school zonings, inducing residential sorting in the dense zoning that had an advantage of less admission uncertainty. Our study shows that households resort to SDH with higher admission probability in response to uncertainty from the lottery. This also suggests that the new pattern of school and residential location choice restricted the policy's effectiveness, which was an unintended consequence from policymaker's perspective.

This paper advances our understanding of how school admission uncertainty shapes households' residential location decision. Our study also contributes to the emerging literature on the effect of school lottery on school quality capitalization and school choice in China. Our findings have policy implications for developing countries, where school enrollment systems are mostly based on residence-based one-to-one assignment. The parental decision pattern revealed in this paper may inspire policymakers to better resolve the dilemma of intensive competition for public elite schools through residential location choice.

References

Andreyeva, E. and Patrick, C. (2017). Paying for priority in school choice: Capitalization effects of charter school admission zones. *Journal of Urban Economics*, 100:19–32.

Avery, C. and Pathak, P. A. (2021). The Distributional Consequences of Public School Choice. *American Economic Review*, 111(1):129–152.

Baum-Snow, N. and Lutz, B. F. (2011). School Desegregation, School Choice, and Changes in Residential Location Patterns by Race. *American Economic Review*, 101(7):3019–3046.

Bayer, P., Ferreira, F., and McMillan, R. (2007). A Unified Framework for Measuring Preferences for Schools and Neighborhoods. *Journal of Political Economy*, 115(4):588–638.

Bibler, A. and Billings, S. B. (2020). Win or Lose: Residential Sorting After a School Choice Lottery. *The Review of Economics and Statistics*, 102(3):457–472.

Black, S. E. (1999). Do Better Schools Matter? Parental Valuation of Elementary Education. *The Quarterly Journal of Economics*, 114(2):577–599.

Bonilla-Mejía, L., Lopez, E., and McMillen, D. (2020). House prices and school choice: Evidence from Chicago's magnet schools' proximity lottery. *Journal of Regional Science*, 60(1):33–55.

Brunner, E. J., Cho, S.-W., and Reback, R. (2012). Mobility, housing markets, and schools: Estimating the effects of inter-district choice programs. *Journal of Public Economics*, 96(7):604–614.

Callaway, B. and Sant'Anna, P. H. (2020). Difference-in-Differences with multiple time periods. *Journal of Econometrics*, page S0304407620303948.

Chan, J., Fang, X., Wang, Z., Zai, X., and Zhang, Q. (2020). Valuing primary schools in urban China. *Journal of Urban Economics*, 115:103183.

Chen, J. and Li, R. (2023). Pay for elite private schools or pay for higher housing prices? Evidence from an exogenous policy shock. *Journal of Housing Economics*, 60:101934.

de Chaisemartin, C. and D'Haultfœuille, X. (2020). Two-Way Fixed Effects Estimators with Heterogeneous Treatment Effects. *American Economic Review*, 110(9):2964–2996.

Ely, T. L. and Teske, P. (2015). Implications of Public School Choice for Residential Location Decisions. *Urban Affairs Review*, 51(2):175–204.

Feng, H. and Lu, M. (2013). School quality and housing prices: Empirical evidence from a natural experiment in Shanghai, China. *Journal of Housing Economics*, 22(4):291–307.

Ferreyra, M. M. (2007). Estimating the Effects of Private School Vouchers in Multidistrict Economies. *American Economic Review*, 97(3):789–817.

Goodman-Bacon, A. (2021). Difference-in-differences with variation in treatment timing. *Journal of Econometrics*, page S0304407621001445.

Han, J., Cui, L., and Yu, H. (2021a). Pricing the value of the chance to gain admission to an elite senior high school in Beijing: The effect of the LDHSE policy on resale housing prices. *Cities*, 115:103238.

Han, X., Shen, Y., and Zhao, B. (2021b). Winning at the starting line: The primary school premium and housing prices in Beijing. *China Economic Quarterly International*, 1(1):29–42.

Huang, B., He, X., Xu, L., and Zhu, Y. (2020). Elite school designation and housing prices-quasi-experimental evidence from Beijing, China80. *Journal of Housing Economics*, 50:101730.

Jin, Z., Wang, X., and Huang, B. (2023). The enrolment reform of schools and housing price: Empirical evidence from Shanghai, China. *International Review of Economics & Finance*, 84:262–273.

Lei, S., Lin, L., Jian, T., and Zhuang, J. (2023). Evaluation on the Effect of "Opportunity Equalization" Measures in Basic Education: Taking the "Multi-school Zoning" Policy in Xicheng District of Beijing as an Example. *Journal of Finance and Economics*, 49(07):48–62.

Park, M. and Hahm, D. W. (2023). Location Choice, Commuting, and School Choice.

Snyder, T. D., de Brey, C., and Dillow, S. A. (2019). Digest of Education Statistics 2017, 53rd Edition. NCES 2018-070.

National Center for Education Statistics.

Sun, L. and Abraham, S. (2021). Estimating dynamic treatment effects in event studies with heterogeneous treatment effects. *Journal of Econometrics*, 225(2):175–199.

Zheng, S., Hu, W., and Wang, R. (2016). How Much Is a Good School Worth in Beijing? Identifying Price Premium with Paired Resale and Rental Data. *The Journal of Real Estate Finance and Economics*, 53(2):184–199.

Figures and Tables

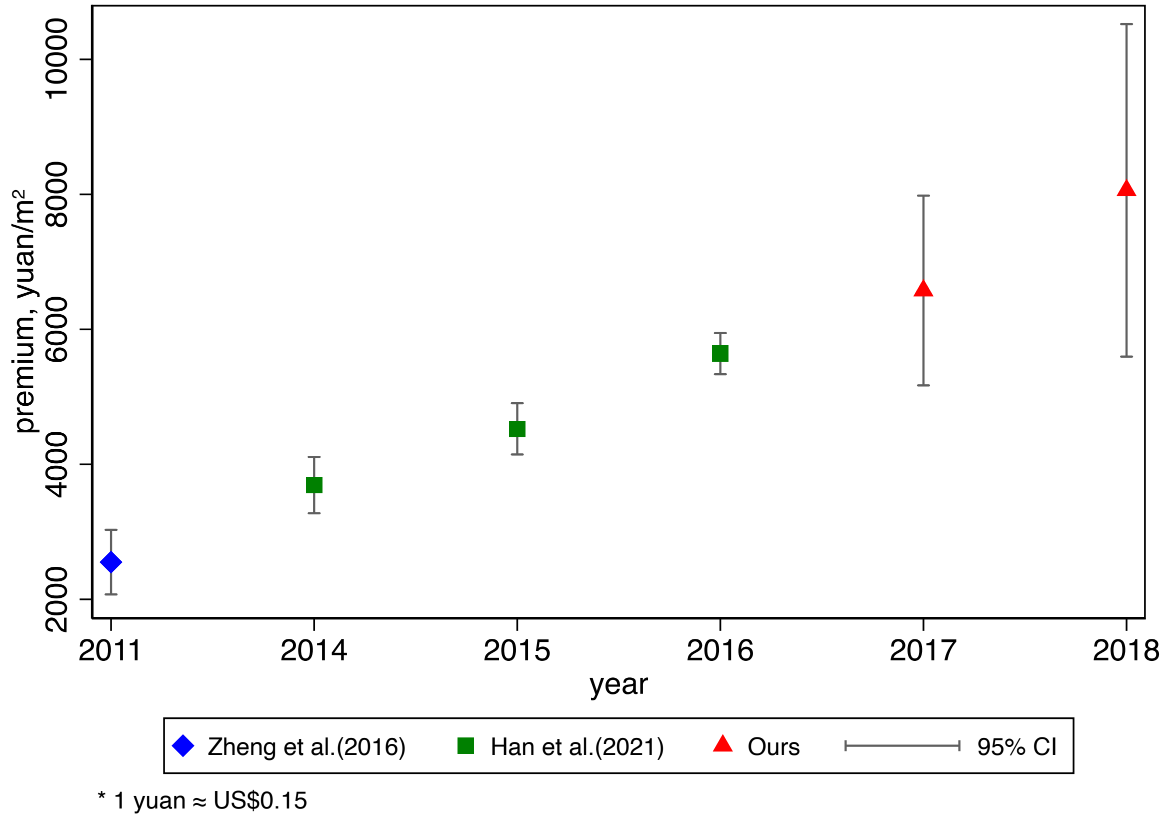

Figure 1: An increasing trend of school-quality premium in Beijing.

Note: The purple square refers to the school-quality premium estimated by Zheng et al. (2016) in 2011; the green squares refer to the school-quality premium estimated by Han et al. (2021b); the red triangles refer to the school-quality estimated by us.

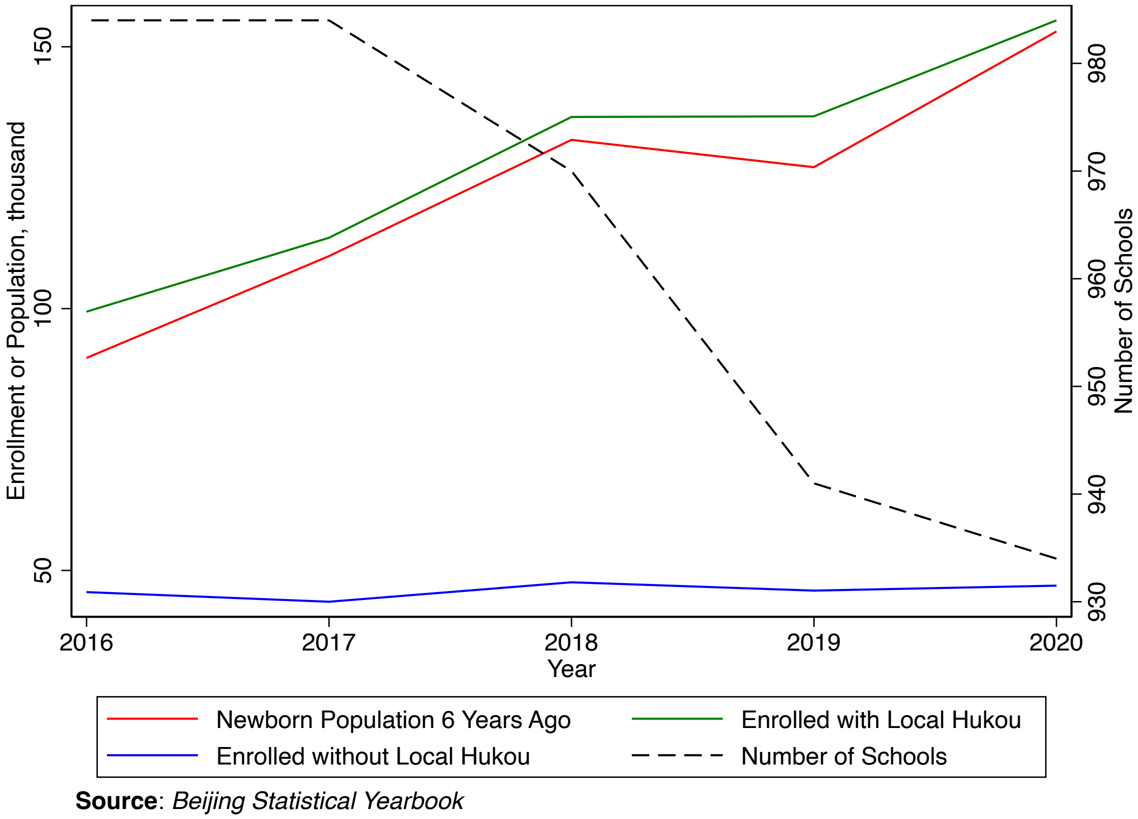

Figure 2: School capacity increasingly overwhelmed in Beijing.

Note: (1) The red curve represents the newborn population in Beijing 6 years ago. (2) The green curve represents the number of newly enrolled elementary school students with Beijing's local Hukou. (3) The blue curve represents the number of newly enrolled elementary school students without Beijing's local Hukou. (4) The black dashed curve represents the number of elementary schools in Beijing.

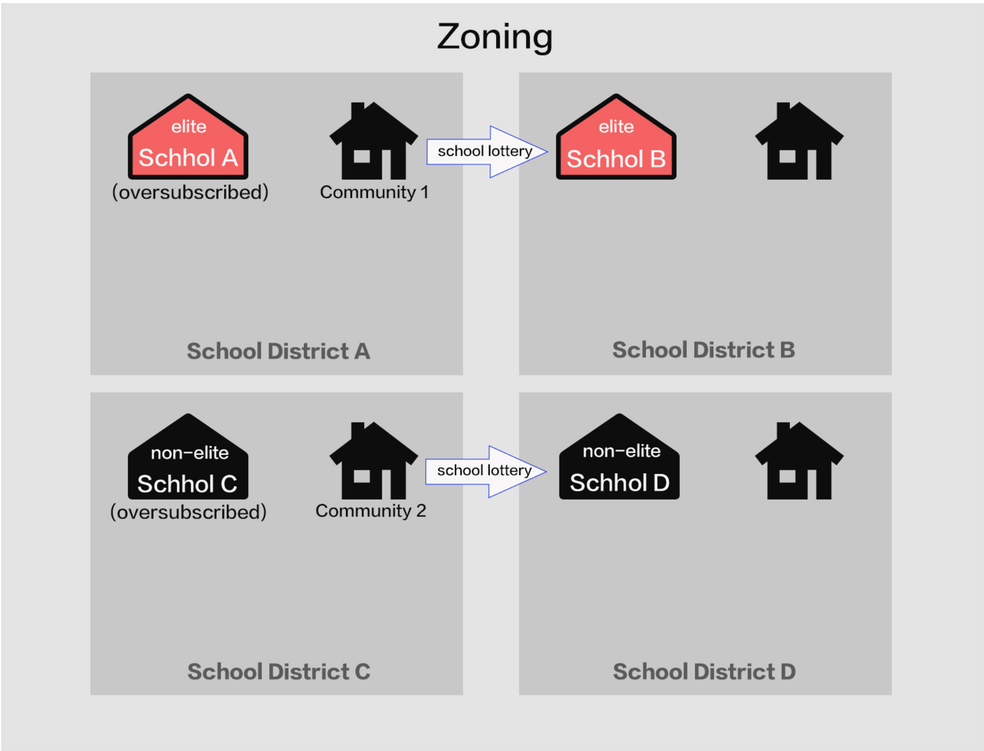

Figure 3: An illustration for the school lottery in a zoning.

Note: (1) Schools in red color are elite schools, while schools in black color are non-elite schools. (2) "Oversubscribed" means that the number of applicants exceeds the enrollment plan. (3) The arrow of the "school lottery" stands for some students who are assigned to the neighboring school under the school lottery. (4) The four school districts constitute a zoning.

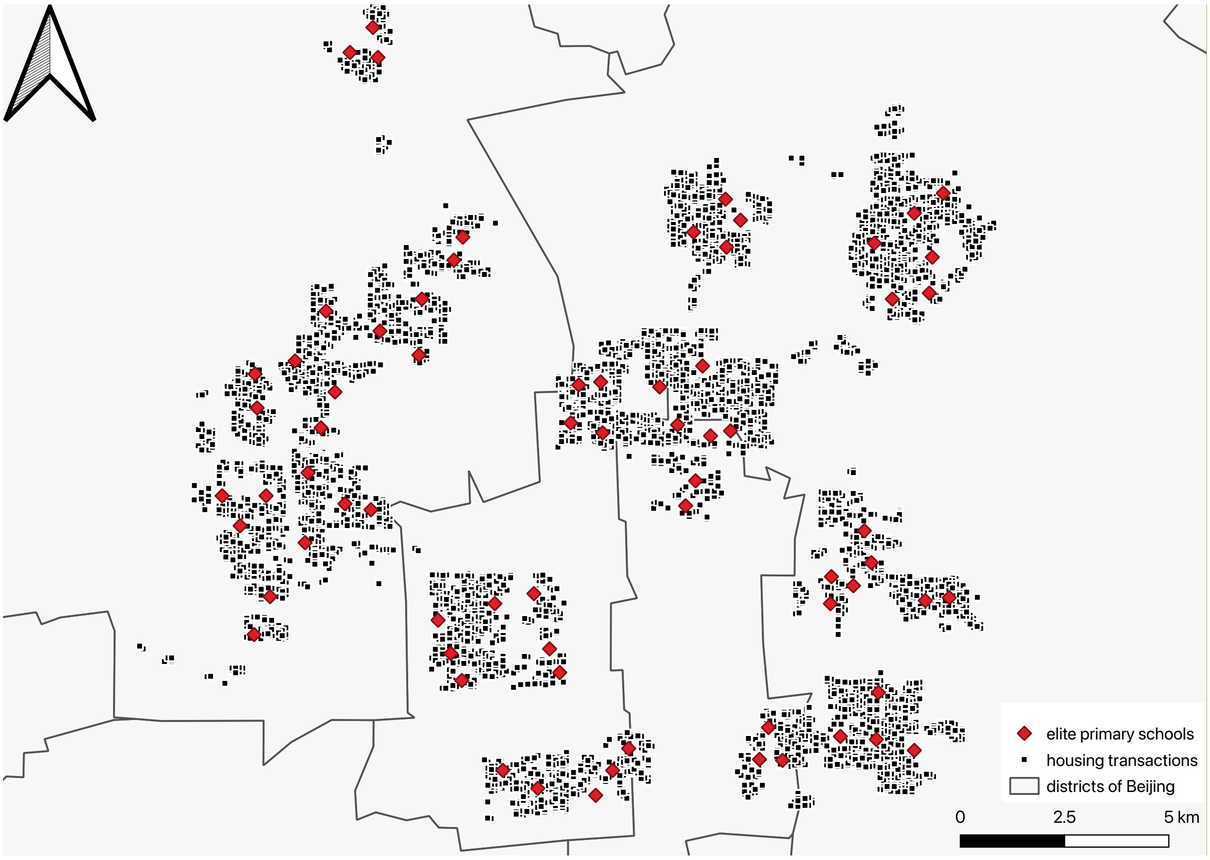

Figure 4: Dense zonings.

Note: Figure 4 and Figure 5 are made by the GIS software. Housing transactions are the transaction records with latitude and longitude coordinates in our dataset.

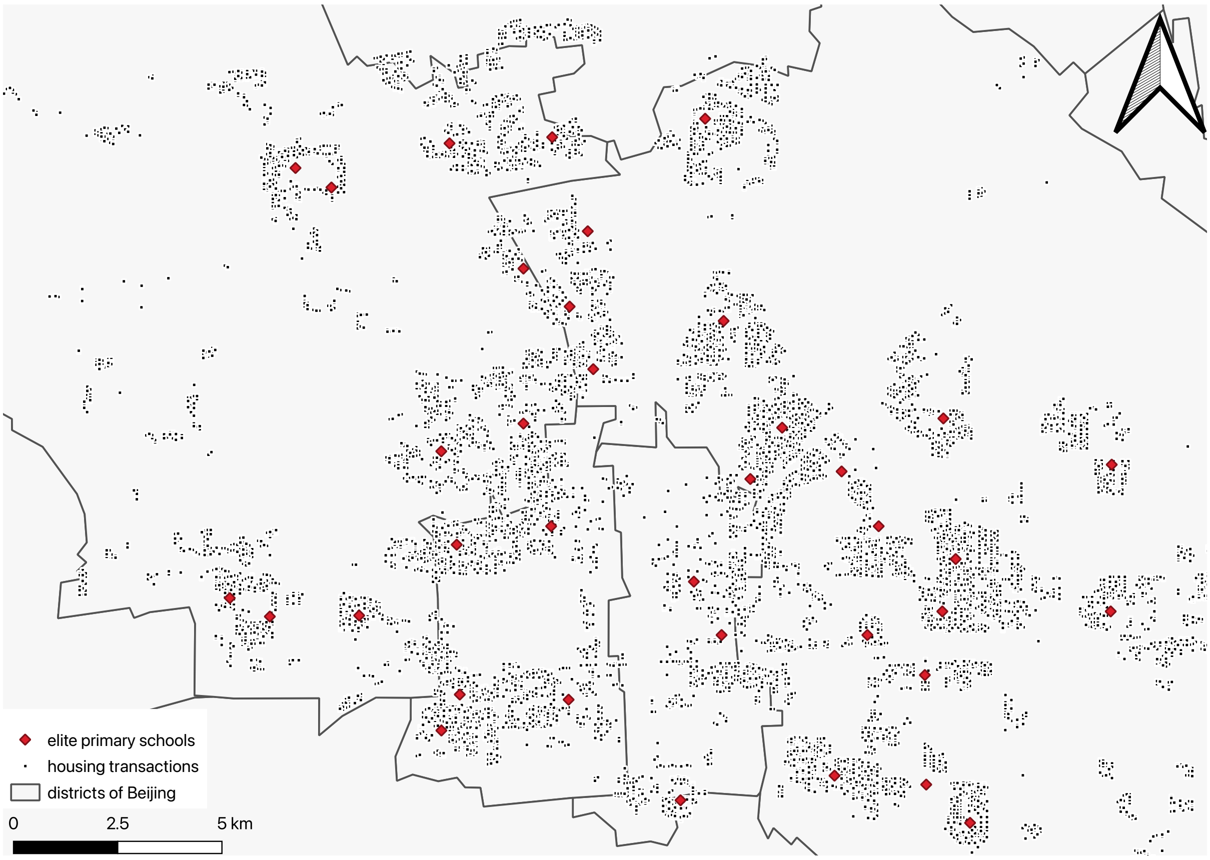

Figure 5: Other zonings.

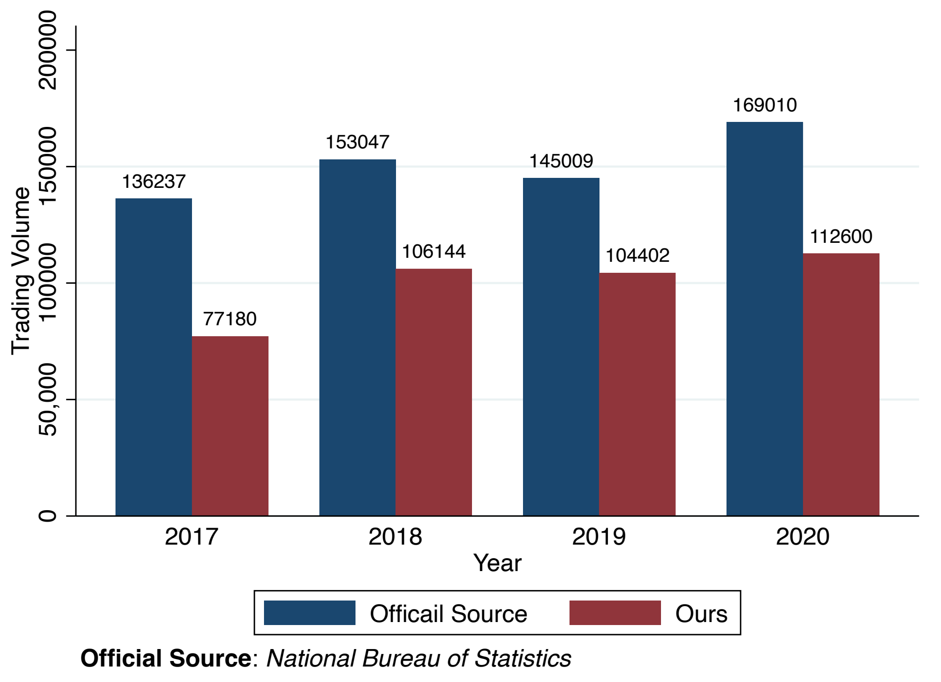

Figure 6: Transaction volume of second-hand houses in Beijing.

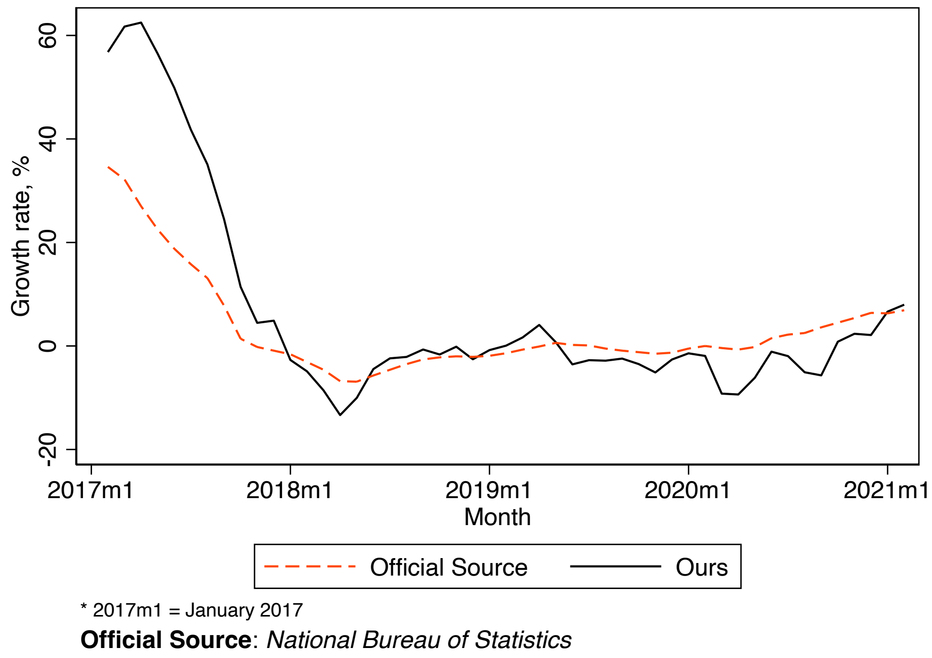

Figure 7: Year-over-year growth rate of housing prices.

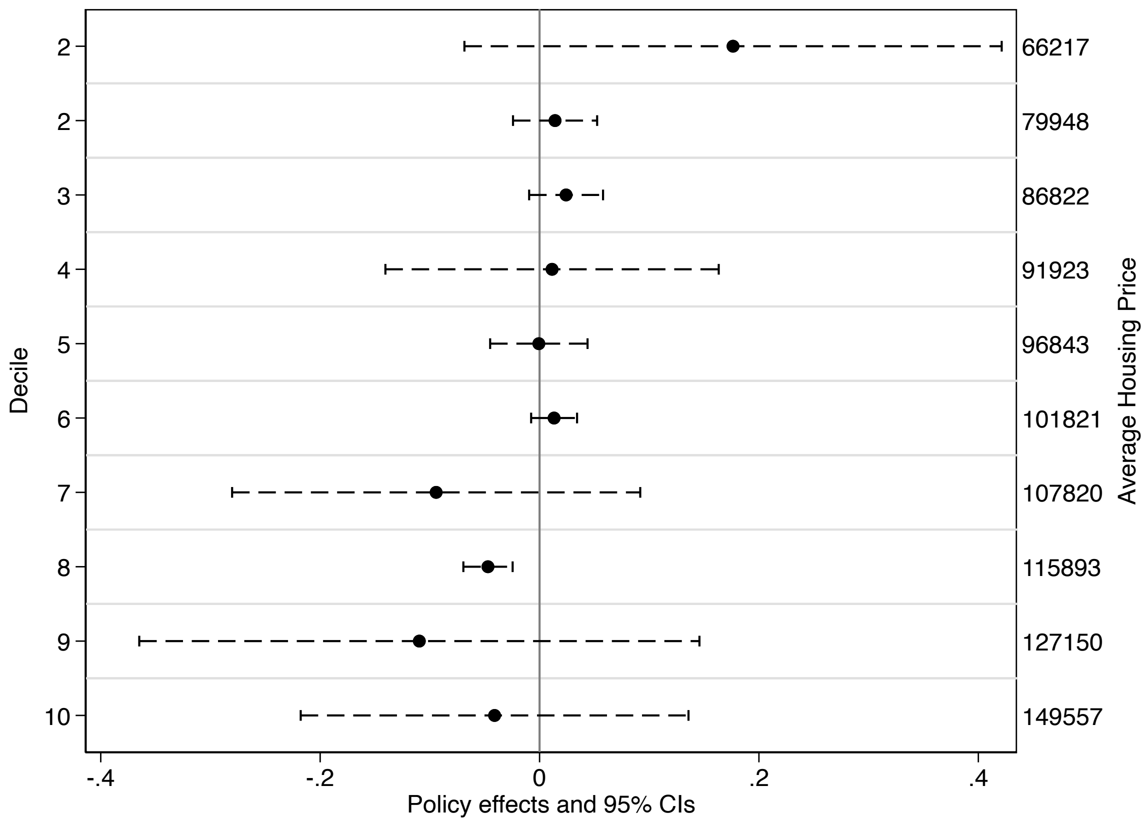

Figure 8: Effects of school lottery by Housing Price Decile.

Note: the average housing prices of the three kinds of SDHs are as follows: 121,890 yuan/m^2 (Tier 1 SDHs), 102,901 yuan/m^2 (Tier 2 SDHs), and 95,304 yuan/m^2 (other SDHs). The specifications of the regressions above are the same as those in Table 4.

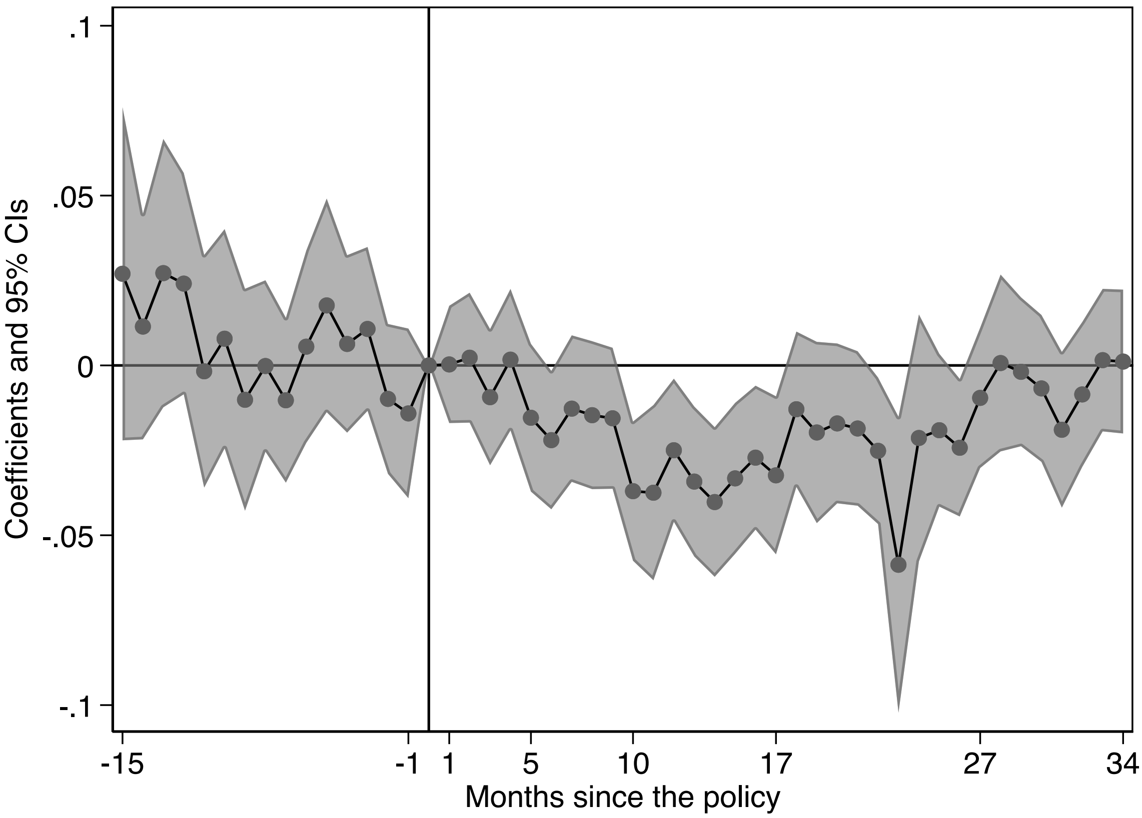

Figure 9: Event study of the policy.

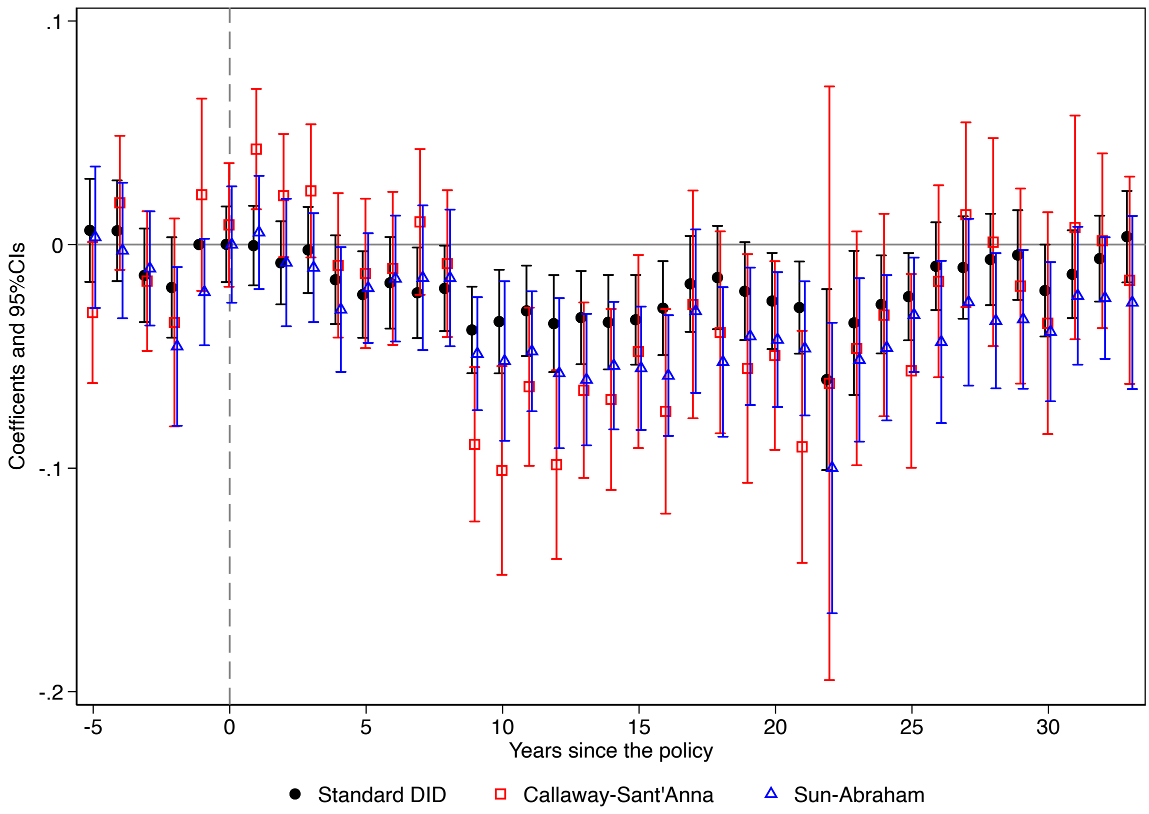

Figure 10: Event study with alternative robust DID models.

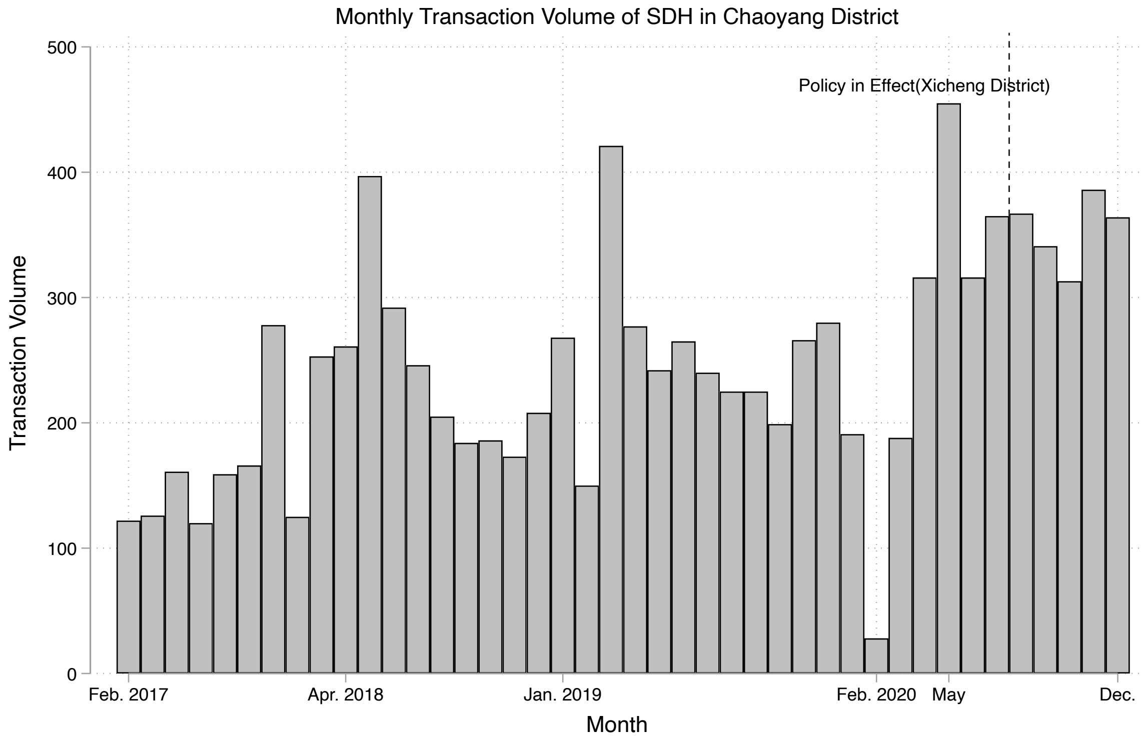

Figure A1: Monthly Transaction Volume of School District Homes in Chaoyang District.

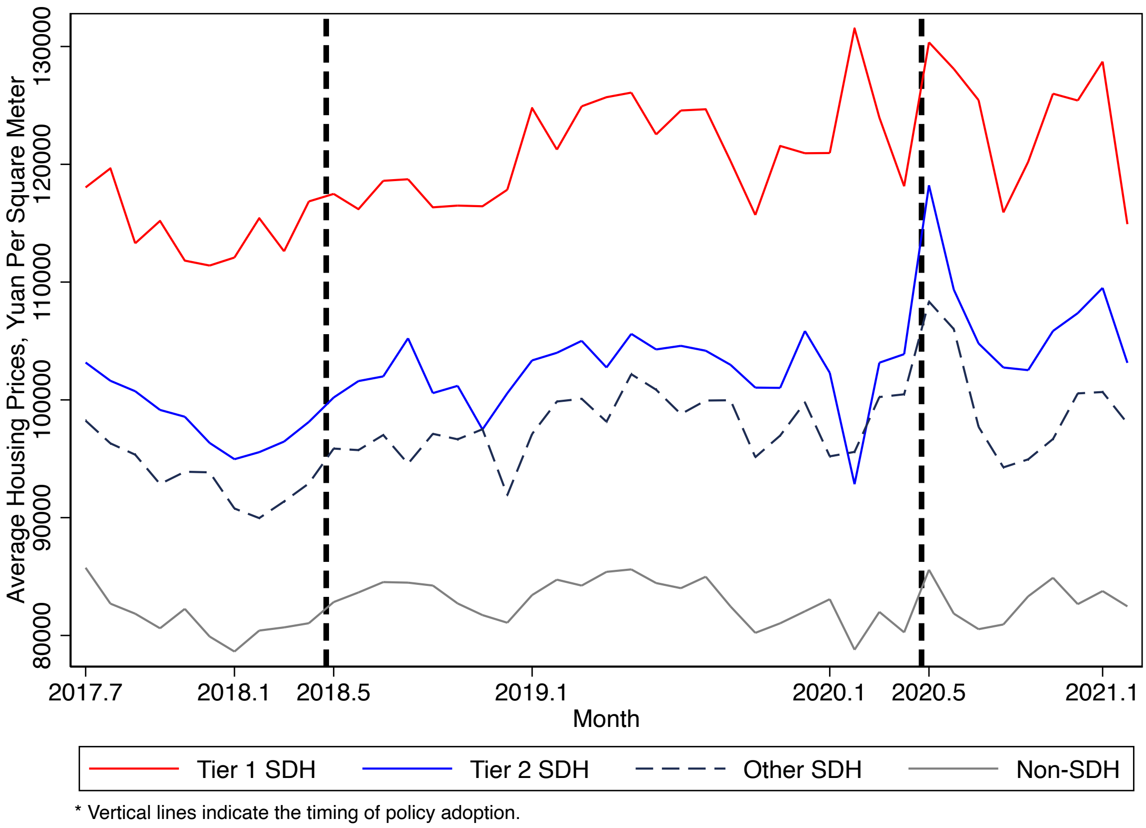

Figure A2: Time trend of average housing prices.

Note: (1) This figure depicts the average housing prices of SDHs and non-SDHs on a monthly basis. (2) The black vertical dash lines represent two timings of policy adoption in DHX.

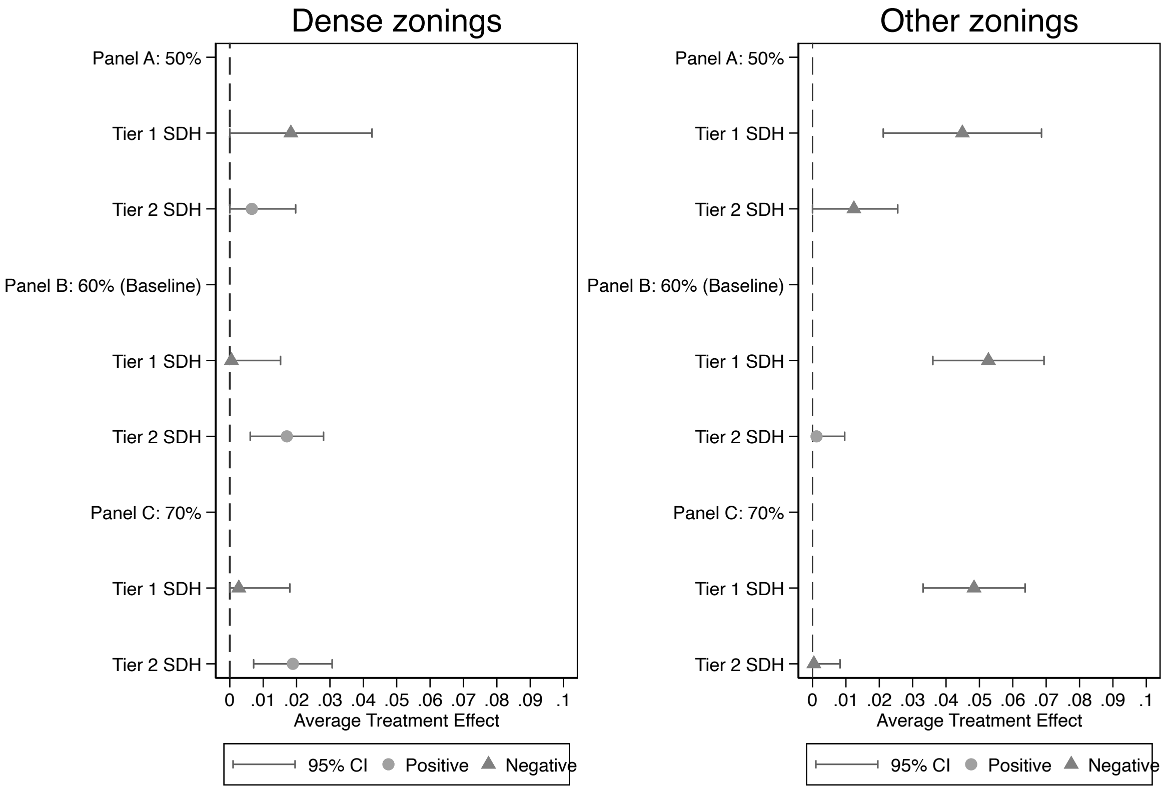

Figure A3: Regression results of balanced and unbalanced slices with different ratios.

Note: (1) The left figure depicts the policy's treatment effects on SDHs with different proportions of elite schools in the dense zonings, while the right one depicts those in other zonings. (2) Panel A, B, and C set the proportion of elite schools in the dense zonings as 50%, 60%, and 70%, respectively.

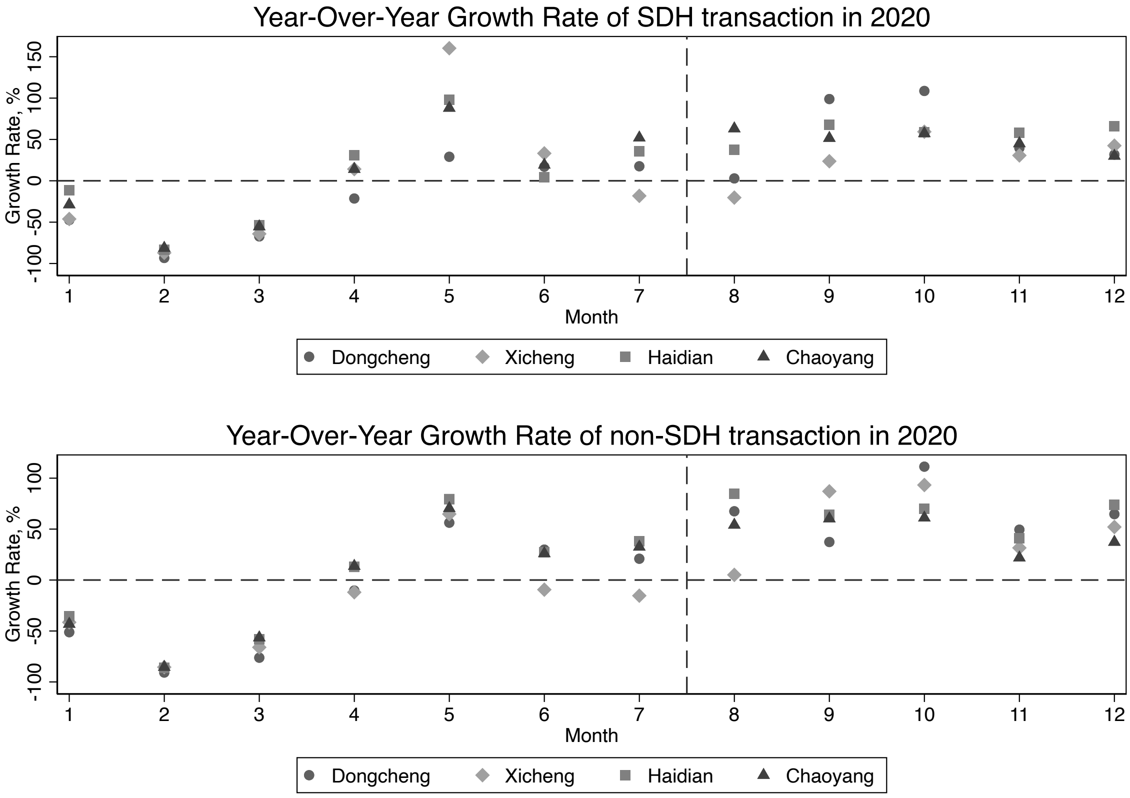

Figure A4: Year-over-year change in SDH transactions in 2020.

Table 1: Descriptive statistics

	(1)	(2)	(3)	(4)	(5)
	Non-SDH	SDH	Tier 1 SDH	Tier 2 SDH	Other SDH
Dependent variable					
Housing price(RMB Yuan/ m^2)	83166	103284	121,890	102,901	95,304
Architectural features variables					
Area(m^2)	74.1	71	74.3	70.4	70.7
Well-decorated (Yes=1)	0.45	0.36	0.34	0.34	0.39
Elevator (Yes=1)	0.52	0.49	0.60	0.50	0.51
Entrance guard (Yes=1)	0.77	0.74	0.70	0.75	0.71
Building age (Year)	24.60	28.55	25.79	29.68	28.12
Community characteristics variables					
Monthly management fee (Yuan/ m^2)	1.46	1.42	1.59	1.38	1.41
Plant area (%)	28.44	26.47	25.34	26.93	26.16
Distance to CBD (km)	7.06	6.88	6.12	6.02	5.99
A hospital within 500m (Yes = 1)	0.51	0.56	0.37	0.59	0.59
A supermarket within 500m (Yes = 1)	0.88	0.91	0.90	0.92	0.90
Observations	33,762	28,537	3,763	14,962	9,792

Notes: The table reports the mean of each variable.

Table 2: Treatment and control group designation in staggered DID

Group Designation	Housing Category	Policy Timing
Treatment Group	Dongcheng SDHs, Haidian SDHs	April 18, 2018
	Xicheng SDHs	April 20, 2020
Control Group	Non-SDHs of DHX	Null

Table 3: School-quality premiums of SDHs before the school lottery

	Dependent variable: ln(housing price)					
	No match	No match	Match	Match	Match	Match
	(1)	(2)	(3)	(4)	(5)	(6)
SDH	0.0930***		0.0797***		0.0770***	
	(0.0101)		(0.0115)		(0.0108)	
Tier 1 SDH		0.1655***		0.1619***		0.1600***
		(0.0173)		(0.0221)		(0.0244)
Tier 2 SDH		0.0989***		0.0812***		0.0785***
		(0.0112)		(0.0136)		(0.0123)
Other SDH		0.0690***		0.0596***		0.0530***
		(0.0129)		(0.0138)		(0.0149)
Boundary FE	No	No	Yes	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes	Yes	Yes	Yes
Covariates	Yes	Yes	Yes	Yes	Yes	Yes
Match distance	No	No	Unlimited	Unlimited	500m	500m
Observations	21,484	21,484	21,324	21,324	20,396	20,396
R-squared	0.753	0.757	0.843	0.844	0.841	0.842

Notes: (1) "Match" stands for matching the SDH with the nearest non-SDH. While "unlimited" stands for not limiting the matching distance, "500m" is setting the matching distance as 500 meters. (2) Standard errors are clustered at the community level and are reported in parentheses, * p < 0.1, ** p < 0.05, *** p < 0.01.

Table 4: Policy effects on the school-quality premiums

	Dependent variable: ln(housing price)		
	SDH	Tier 1 SDH	Tier 2 SDH
	(1)	(2)	(3)
Policy	-0.0118**	-0.0531***	-0.0032
	(0.0059)	(0.0113)	(0.0075)
Sample	$\sum_{i=1}^{4} S_i$	$S_1 + S_4$	$S_2 + S_4$
Covariates	Yes	Yes	Yes
Boundary FE	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes
Observations	57,969	35,833	46,366
R-squared	0.848	0.875	0.853

Notes: Standard errors are clustered at the community level and reported in parentheses, * p < 0.1, ** p < 0.05, *** p < 0.01.

Table 5: Policy effects on school-quality premiums in different zonings

	Dependent variable: ln(housing price)		
	Tier 1 SDH	Tier 2 SDH	Gap
	(1)	(2)	(3)
Panel A: Dense Zonings			
Policy	-0.0005	0.0171***	-0.0151**
	(0.0075)	(0.0056)	(0.0074)
Sample	S_1+S_4	S_2+S_4	
Covariates & FE	Yes	Yes	
Observations	7,465	13,235	
R-squared	0.856	0.783	
Panel B: Other Zonings			
Policy	-0.0527***	0.0012	-0.0402***
	(0.0085)	(0.0043)	(0.0078)
Sample	S_1+S_4	S_2+S_4	
Covariates & FE	Yes	Yes	
Observations	28,670	33,424	
R-squared	0.846	0.831	
Panel C: Dense Zonings v.s. Other Zonings (DDD)			
$Policy \cdot DZ$	0.0555***	0.0147**	
	(0.0122)	(0.0072)	
Sample	S_1+S_4	S_2+S_4	
Covariates & FE	Yes	Yes	
Observations	36,141	46,670	
R-squared	0.868	0.842	

Note: (1) Column (3) shows the gap in treatment effects between Tier 1 SDH and Tier 2 SDH, which is the coefficient of interaction between the policy and the dummy of Tier 1 SDH. (2) Panel C leverages triple difference regressions to show the relative premium increases of dense zonings (DZ) compared to other zonings. We add dummy variable "DZ" (a dense zoning if DZ = 1) into the specification, and the $Policy \cdot DZ$ is the interaction term that shows the difference of policy effect between two kinds of zonings.

Table 6: Placebo test: policy effect on housing price premium of SDHs using Chaoyang's samples

	Dependent variable: ln(housing price)		
	SDH	Tier 1 SDH	Tier 2 SDH
	(1)	(2)	(3)
Panel A: Policy's timing same with Dongcheng and Haidian			
Policy	0.0218**	0.0532**	0.0259**
	(0.0094)	(0.0235)	(0.0106)
Sample	$\sum_{i=1}^{4} S_i$	$S_1 + S_4$	$S_2 + S_4$
Covariates & FE	Yes	Yes	Yes
Observations	66,649	58,933	63,128
R-squared	0.731	0.739	0.736
Panel B: Policy's timing same with Xicheng			
Policy	0.0345***	0.0521***	0.0384***
	(0.0083)	(0.0079)	(0.0120)
Sample	$\sum_{i=1}^{4} S_i$	$S_1 + S_4$	$S_2 + S_4$
Covariates & FE	Yes	Yes	Yes
Observations	66,649	58,933	63,128
R-squared	0.732	0.74	0.737

Table 7: Robustness check: Using Chaoyang SDH as the control group

	Dependent variable: ln(housing price)		
	SDH	Tier 1 SDH	Tier 2 SDH
	(1)	(2)	(3)
Policy	-0.0298**	-0.0634***	-0.0172
	(0.0128)	(0.0230)	(0.0158)
Sample	$\sum_{i=1}^{4} S_i$	$S_1 + S_4$	$S_2 + S_4$
Boundary FE	No	No	No
Covariates	Yes	Yes	Yes
Observations	38,615	5,247	20,961
R-squared	0.51	0.7245	0.5604

Note: We did not include boundary fixed effects because Chaoyang SDHs are spatially separated with the SDHs in DHX.

Table A1: Comparisons between Chaoyang and DHX

	Dongcheng	Xicheng	Haidian	**Chaoyang**
Population (thousand)	822	1,179	3,358	**3,605**
GDP (million yuan)	24.26	42.44	64.80	**60.94**
Per capita GDP (thousand yuan)	295	360	193	**169**
Per capita disposible income (yuan)	75,547	81,678	78,178	**70,746**
Number of top-class elementary school	4	6	5	**3**
Number of tier 2 elementary school	12	15	16	**13**
Total number of elementary school	61	58	84	**83**
Elementary school enrolment	12,025	18,328	32,484	**28,505**