Valuing primary schools in urban China *

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Abstract

We study the effect of school quality on housing prices in urban China. Our objective is to provide an estimate of the school-quality premium based on the best available data. To account for unobserved neighborhood characteristics, we adopt the boundary-discontinuity design of Black (1999) and the matching strategy proposed by Fack and Grenet (2010). The results suggest that parents value public primary schools that have outstanding records in academic tournaments. The school-quality premium is highly non-linear. While a tournament superstar—a school above the 90th percentile in tournament performance—causes housing prices in its neighborhood to increase by 14 percent, or about 430,000 RMB, the price difference between non-superstar schools is small.

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Introduction

Chinese parents often say that they do not want to let their children "fall behind at the starting line." Competition for places in the best primary schools is thus intense. As in the U.S. and other developed countries, admission to public primary schools in urban China is residence-based. But while homeowners and renters are treated equally in the U.S., the Chinese rule assigns a higher priority to homeowners. In practice, to send a child to a popular public primary school, a Chinese household must own property in the school's attendance zone. The extent to which this adds to skyrocketing housing prices in urban China is hotly debated.[1] Yet little rigorous research has been done to estimate the school-quality premium in housing markets in China.

The objective of this paper is to provide an estimate of the school-quality premium based on the best available data. We focus on Shanghai, the most populous city in China.[2] We collect data on housing transactions and tournament performance for 280 public primary schools in seven urban districts in Shanghai. To account for unobserved neighborhood characteristics that may correlate with school quality, we apply the boundary-discontinuity design (BDD) of Black (1999), as well as the cross-boundary differential model of Fack and Grenet (2010).

In the literature, it is standard to measure school quality by student test scores.[3] In China,

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1 For example, see:
https://www.usatoday.com/story/news/world/2013/07/04/china-cost-of-education/2489899/,
http://www.globaltimes.cn/content/991379.shtml,
and http://www.chinadaily.com.cn/a/201808/27/WS5b8356c0a310add14f387ddd.html.

2 According to the *National Bureau of Statistics* in China, Shanghai had 24 million residents in 2015.

3 For example, see Black (1999), Downes and Zabel (2002), Gibbons and Machin (2003, 2006), Figlio and Lucas (2004), Bayer, Ferreira and McMillan (2007), Hastings and Weinstein (2008), Dhar and Ross

there are no standardized tests at the primary-school level, and to discourage harmful competition, primary schools are forbidden to publicize where they send their graduates. In this paper, we measure school quality by a primary school's performance in mathematics and language tournaments, which, in the absence of standardized test scores, has become an important indicator of school quality.

Using tournament performance as a measure of school quality has pros and cons. On the minus side, tournament performance may reflect exam-taking skills rather than genuine academic abilities, and, as participation in tournaments is voluntary, it may not be an accurate measure for schools where few students enter the tournaments. But on the plus side, tournament performance is publicly observable and, because winning a prize in a tournament can significantly enhance the chance of gaining admission to a selective middle school, the tournament record of a school may indeed be what many parents care about most.

The existing literature has shown that a one-standard-deviation increase in school test scores raises local housing prices by 2 to 4 percent.[4] For example, Black (1999) finds that a one-standard-deviation increase in test scores in primary schools in suburban Boston is associated with a 2.1 percent increase in housing prices. Gibbons and Machin (2003) estimate this increase to be 3.7 percent for British primary schools. Using data on French middle schools, Fack and Grenet (2010) show that the increase is between 1.4 and 2.4 percent. See Table 1 of Black and Machin (2011) which summarizes the findings of previous research on the

(2012), and Gibbons, Machin and Silva (2013). In many other countries, information about schools' performance on standardized tests is regularly publicized by local authorities to facilitate parents' school choices.

[4] For reviews, see Black and Machin (2011), and Nguyen-Hoang and Yinger (2011).

capitalization effect of school quality. Our estimation suggests that a one-standard-deviation increase in the tournament performance of primary schools in Shanghai is associated with a 2.4-percent increase in housing prices, which is in line with the literature. The willingness to pay for school quality, however, is highly convex. While a small set of "superstar" schools commands a very large premium, the price difference between non-superstar schools is small.

To capture this non-linearity, we divide the schools in our sample into four categories according to their tournament performance rankings: (i) above the 90th percentile (tournament superstars); (ii) between the 75th and 90th percentile; (iii) between the 50th and 75th percentile; and (iv) below the 50th percentile. Both the boundary-fixed-effect model and the cross-boundary-differential model yield similar estimates for the school-quality premium. According to the latter, a tournament superstar commands a premium of 14 percent, or about 430,000 RMB (65,000 USD, using the exchange rate of June 2016) compared to a school in the bottom half. However, schools between the 75th and 90th percentiles have a marginally significant premium of just 5 percent, while schools between the 50th and 75th percentiles have a premium close to zero. The results are robust to alternative measures of tournament performance and alternative cutoff levels.

A potential problem with the BDD is that households with heterogeneous preferences for school quality may sort across zone boundaries. In this case, the value of these traits would also be captured by the school-quality variables. Previous studies have shown that, in the U.S., households on the better-school side of a boundary have higher income and more education, and are less likely to be black (Kane, Riegg, and Staiger, 2006; Bayer et al., 2007). One can try to control for neighborhood characteristics that may correlate with a stronger preference for school quality. In practice, however, one can never be sure that the list is complete. In this paper, we take advantage of the home-ownership bias of the Chinese system to address this issue. Rather than treating homeowners and renters equally, the Chinese rule assigns a higher priority to homeowners. Since renters inside the attendance zone of a sought-after public school cannot send their children to the school (see Section 2 for details), the average rent in a neighborhood should capture the value of all neighborhood characteristics other than the quality of the school. We find that all of our neighborhood attributes, including rents, change continuously at the zone boundary. This suggests that sorting by quality preference is not a serious issue in our boundary sample.

While school-zone boundaries are fairly stable over time, small adjustments do happen occasionally in the city-center area due to brownfield redevelopment or in suburban areas when new schools are opened. As corroborating evidence, we use a difference-in-differences (DID) strategy to estimate the price effect of a boundary adjustment. This quasi-experimental approach allows us to deal with the confounding effect of unobserved neighborhood characteristics.[5] We find that, on average, moving from the attendance zone of a tournament superstar to that of a school in the bottom half reduces housing prices by about 13 percent, which is slightly smaller than the estimate in the cross-sectional analysis. Considering that households may worry about whether the adjustment is permanent, the DID estimate is likely to be biased downward.

[5] A number of papers study the effect on housing prices of school-quality change induced by school openings or closures or by the introduction, re-drawing, or withdrawal of school-attendance boundaries (e.g., Bogart and Cromwell, 2000; Reback, 2005; Kane et al., 2006; Ries and Somerville, 2010; Machin and Salvanes, 2016).

Thus, both the cross-section and DID estimates suggest that there is a small group of "elites" among public primary schools in Shanghai. One possible explanation for this "winner-take-all" property is that tournament performance is valued only by parents who try to compete for places for their children in highly selective middle schools. To such parents, a better-than-average school that does not help their children to make the cut at a selective middle school may be of little additional value.

The high housing prices in Shanghai mean that few of the households who do not currently own properties can afford to buy one.[6] The current policy of favoring homeowners, therefore, effectively excludes children of many poorer households from the best public primary schools. In an attempt to equalize access, the Chinese government has implemented a pilot program in another major city that gives renters equal access to public schools.[7] Our research suggests that, in cities like Shanghai, where the willingness to pay for the best schools is very high, such a policy would be likely to substantially increase the demand for places at superstar schools, as well as the rent in their attendance zones. The policy would therefore benefit current property owners in the attendance zones of superstar schools. Whether it would benefit poorer households is less clear as households who can afford the current school premium are also

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[6] According to NUMBEO (www.numbeo.com), in 2016, Shanghai had a house price-to-income ratio of 30.23, much higher than the ratios in Tokyo (25.9), Seoul (16.64), Taipei (26.02), Singapore (23.17), New York (21.60), San Francisco (13.70), Paris (17.99), and Berlin (8.59). The other least affordable cities include Hong Kong (37.57), London (33.51), Beijing (33.45), and Shenzhen (30.03).

[7] In July 2017, the city government of Guangzhou initiated a new regulation that gives renters and homeowners equal rights to educational resources. Guangzhou is one of the largest cities in China. It had a population of 13.5 million in 2015. See http://www.chinadaily.com.cn/business/2017-07/19/content_30170754.htm.

likely to be willing to pay higher rents to send their children to superstar schools.

Previous attempts to estimate the capitalization of primary-school quality in China have focused on the differences between historical magnet schools (*zhongdian xuexiao*) and non-magnet schools. Zheng, Hu, and Wang (2016) find that in Beijing, housing units in the attendance zone of a historical magnet school carry a premium of about 8.1 percent. Zhang and Chen (2018) find a historical-magnet-school premium of about 6.5 percent in Shanghai. Because the magnet-school status is dichotomous, it does not reveal whether school premium varies non-linearly with performance. Because the magnet school program, which began in the late 1970s, was phased out at the primary- and middle-school levels in the 1990s, a school's magnet-school status may not fully capture its current quality. For example, any school that opened after the program was abolished, by definition, cannot be a historical magnet school. Tournament performance, by contrast, may provide a more current measure of quality. In our analysis, after controlling for tournament performance, the premium for historical magnet schools is small and insignificant.

The rest of the paper is organized as follows. Section 2 describes the features of China's educational system and admission rules. Section 3 presents the empirical strategy. Section 4 introduces the data. Section 5 presents the main results. Section 6 presents supporting evidence. Section 7 concludes.

2. Chinese educational system

In Shanghai, pre-college formal education lasts twelve years: five in primary school, four in middle school, and three in high school. Primary-school and middle-school education are compulsory, and public education during the compulsory stage is tuition-free. In 2012, 95.2 percent of primary-school students in the urban area of Shanghai attended a public school.[8] The Shanghai system is largely representative of that of China, with the exception that in most of China, primary education lasts for six years and middle-school education lasts for three.

Admission to public primary schools is based on a complex priority system tied to the household registration (*hukou*) system, whereby each household must register an address. Unlike typical residence-based admission systems, the Chinese system does not give the same rights to all households in the attendance zone of a school. Instead, the highest priority is reserved for households that register addresses in the attendance zone of the school *and* own the housing units at their registered addresses. In practice, only homeowners (and not renters) are able to send their children to schools that are in high demand.

Before 1997, public middle schools used a standardized test to admit students. The test was abolished in 1997. Since then, the assignment of public middle schools has been based partly on the registered address of a household and partly on the school performance of a student. Most public middle schools admit only students who live in their attendance zones. But some high-quality public middle schools also admit students with excellent academic records from outside their attendance zones. Private middle schools, which account for about 15 percent of the city's total middle school enrollment, are free to choose their own admissions tests and standards.

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[8] This number is from the website of the Education Committee of Shanghai: http://www.shmec.gov.cn/web/jyzt/zygz11/jyzt_show.php?area_id=3001&article_id=68758. According to the Chinese Household Income Project conducted in nine provinces in 2008, public primary schools account for 95% of total enrollment. These nine provinces include Shanghai, Jiangsu, Zhejiang, Guangdong, Anhui, Henan, Hubei, Chongqing and Sichuan.

About 60 percent of middle-school students attend grammar high schools.[9] Admissions to grammar high schools are largely based on standardized tests and are fiercely competitive. The best students are sorted into a small number of magnet schools (*zhongdian gaozhong)* that have better teachers and facilities. Attending a top high school can greatly enhance a student's chances of gaining admission to one of the elite universities in the country.[10] For example, in 2012, 20 local high schools (out of a total of 249) accounted for 80 percent of the Shanghai students entering one of the top two universities in Shanghai. Among this 80 percent, close to 40 percent came from just four high schools.[11]

Parents who worry about "falling behind at the starting line" compete to send their children to the best primary schools. Because the Shanghai government does not allow primary schools to publicize enrollment data for their graduates, a school's performance in academic tournaments becomes an important indicator of its academic quality. These privately-run tournaments in the subjects of mathematics, English, and Chinese are popular among parents, as winning a tournament prize can significantly increase the chances of admission to a selective private or public middle school, and such schools are more successful in sending their graduates to magnet high schools.[12] To a certain extent, the tournament performance of a school reflects

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[9] According to the National Bureau of Statistics (www.data.stats.gov.cn), about 62 percent of China's middle-school students enrolled in local grammar high schools in 2015. In Shanghai, this ratio was 58 percent in 2015.

[10] Less than 1.6 percent of high school students are able to gain admission to one of the top 39 universities that belong to the esteemed "985-program."

[11] These numbers are calculated based on data collected by the authors.

[12] Private middle schools are typically characterized by high-quality peers, rigorous curricula, ample resources, and outstanding records in middle-to-high-school entrance exams. According to a survey done by the Research and Development Department in China Securities, 18 of the top 20 middle schools ranked based on the average score in the middle-to-high school entrance exam held in 2016 were private schools.

the quality of its teachers and students. But some schools also tailor their curricula to prepare their students for these tournaments.[13] Hence, parents may prefer schools with outstanding tournament records not only because they have high academic standards, but also because they provide better tournament coaching.

3. Estimation methodology

Our goal is to estimate the extent to which the quality of a public primary school is capitalized. A standard hedonic price function has the following form:

$$\ln(p_{i,c,s}) = Z_s\beta + X_i\gamma + K_c\delta + \varepsilon_{i,c,s}\,, \qquad (1)$$

where $p_{i,c,s}$ is the price of house *i* in neighborhood *c* and in the attendance zone of school *s*, Z_s is a vector of school-quality measures, X_i is a vector of housing characteristics, K_c is a vector of neighborhood characteristics, and $\varepsilon_{i,c,s}$ is an error term.

We are mainly interested in β, which captures the average willingness to pay for school quality. The problem of model (1) (the "naïve model") is that the error term may contain unobserved neighborhood attributes that correlate with school quality. To overcome this problem, we adopt the boundary-fixed-effect approach of Black (1999), which compares housing prices on opposite sides of a common boundary between two school-attendance zones. We link each house to the closest zone boundary, and add a set of boundary dummies into the naïve model (1) to obtain

[13] For example, *Mingzhu* Primary School, a tournament superstar, teaches its students with a self-compiled mathematics textbook called "*Wisdom Mathematics*," which is specifically targeted at mathematics tournaments.

$$\ln(p_{i,c,s}) = Z_s\beta + X_i\gamma + K_c\delta + \theta_b + e_{i,c,s}, \quad (2)$$

where *b* denotes the closest boundary and $e_{i,c,s}$ is the error term. We call (2) the boundary-fixed-effect model. The boundary dummies capture unobserved characteristics shared by housing units on both sides of a boundary. To control for spatial price trends from the boundary, all regressions include a quadratic polynomial of the distance between a house and its associated boundary. Following Black (1999), the standard errors are clustered at the school-attendance-zone level to account for the fact that unobserved factors that affect house prices may be spatially correlated within a school attendance zone.

In our sample, the average length of a boundary is 500 meters. It is possible that neighborhood characteristics may change significantly along a boundary. In that case, the boundary dummies may not be able to fully capture the effects of unobserved neighborhood characteristics. To address this issue, we adopt the "matching strategy" proposed by Fack and Grenet (2010), which takes into account the distance between house sales on opposite sides of a boundary.[14]

Following Fack and Grenet (2010), we regress log house price on a full vector of house and neighborhood characteristics and obtain the residuals. We call the residual of house *i* in the attendance zone of school *s* near boundary *b* the *location price* of house *i* and denote it by $\tilde{p}_{i,b,s}$. This residual captures the value of the unobserved neighborhood characteristics of house *i* and the value of public primary school *s*.

For each house *i* in the attendance zone of school *s* near boundary *b* between schools *s*

[14] A similar spatial matching strategy has also been adopted by Gibbons and Machin (2003, 2006), and by Gibbons et al. (2013). In these studies, researchers compare housing prices of the neighborhoods that straddle the boundary of Local Education Authorities in the London metropolitan area.

and s', we construct a control location price, $\tilde{p}_{i',b,s'}$, using the location prices of all sales on the opposite side of the common boundary b:

$$\tilde{p}_{i',b,s'} = \sum_j \frac{\frac{1}{d_{ij}}}{\sum_j \frac{1}{d_{ij}}} \tilde{p}_{j,b,s'} . \tag{3}$$

In (3), the sales on the opposite side of b (indexed by j) are weighted by the inverse of their distances d_{ij} to house i. The control location price captures the value of the unobserved neighborhood characteristics of house i and the value of school s'. The difference between $\tilde{p}_{i,b,s}$ and $\tilde{p}_{i',b,s'}$ therefore measures the difference in the value between schools s and s'. We back out the value of the school characteristics by running a cross-boundary differential regression model:

$$\tilde{p}_{i,b,s} - \tilde{p}_{i',b,s'} = (Z_s - Z_{s'})\beta + (e_{i,b,s} - e_{i',b,s'}) . \tag{4}$$

Following the literature, we cluster the standard errors on the boundary level. To account for the distance between the actual sale and control sale, the regression is weighted by the inverse of the distance between them (i.e., a greater weight is applied to observations that are closer to each other).[15] To control for the spatial price trends from the boundary, all regressions include a quadratic polynomial of the distance between each actual sale and its associated zone boundary (Gibbons et al., 2013).

In addition to the cross-sectional analysis presented above, we study the price effect of a boundary adjustment using a DID strategy. This quasi-experimental approach allows us to deal

[15] The distance between the actual sale and control sale is defined as the weighted geometric mean of the distances between the actual sale and all sales on the opposite side of a boundary, with the weight being the inverse of the distance between the actual sale and the corresponding sale on the opposite side of the common boundary.

with the confounding effect of unobserved neighborhood characteristics. Namely, for the affected housing units, while the school quality changes immediately as a result of the boundary adjustment, other neighborhood characteristics should remain unchanged (at least in the short term). We elaborate on this in Section 6.

4. Data and summary statistics

4.1 House transaction data

The housing-sale data covers 10,472 second-hand house transactions that went through one of the largest real estate brokers in Shanghai from July 2015 through June 2016.[16] For each transaction, we know the date, price, floor area, address, building height (short, middle, or tall), floor level, internal condition (finished or not), and number of bedrooms. Figure 1 plots our housing-sale sample on a map of Shanghai. The mean housing price in our sample is 37,822 RMB (in 2016) per square meter. The average usable floor area is 81 square meters. Panel A of Table 1 reports the summary statistics of the housing units in our sample. To show the representativeness of the transaction sample, we compare the price trends of our data with the trends of the listed prices of all apartments on the market in Shanghai from July 2015 through June 2016, using data obtained from the *China Real Estate Association*. Figure A1 shows that the price trends are very similar.

4.2 Neighborhood characteristics

4.2.1 Residential development project data

[16] In 2016, the market share of this real estate broker was around 10 percent in Shanghai.

Most housing units in Shanghai are condominiums located in residential development projects (RDPs).[17] A typical RDP is built by a single developer on a contiguous land parcel and contains multiple multi-story residential buildings. Housing units in a given RDP share common amenities. We collect data on individual RDPs from the *China Index Academy*, a real estate think tank. Information collected includes the floor-to-area ratio (FAR), green-space ratio, property management fee, building age, distance to the city center (People's Park), and distance to the nearest subway stop.[18,19] We link each housing unit in our sample to the RDP that it belongs to, and use these RDP-level characteristics to capture the physical characteristics of the immediate neighborhood of a housing unit. Panel A of Table 1 reports the summary statistics of the 1,667 RDPs in our sample.

4.2.2. Neighborhood committee data

For the socio-economic characteristics of the neighborhood of a housing unit, we turn to data at the neighborhood-committee level. Neighborhood committees (*juweihui)* are the smallest statistical units in Chinese cities. A typical neighborhood committee in Shanghai covers two or three RDPs. We link each housing unit in our sample to its neighborhood committee.[20] From the full sample of the 2010 Chinese Census, we draw a 10-percent random

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[17] According to the National Bureau of Statistics, the nationwide percentage of condominium units in the newly-built market remained at around 95 percent for the past 10 years (www.data.stats.gov.cn).

[18] A property-management fee is charged by each RDP's property-management company to maintain public goods in the RDP. The total fee is proportional to the total internal floor area of each housing unit. The per-floor-area fee is often associated with the quality of public goods.

[19] FAR is a typical density restriction for land development that imposes an upper limit on the ratio of the total floor area to the lot size of the land to be developed.

[20] It is rare for neighborhood committees to belong to multiple school-attendance zones. We only find such cases in the *Xuhui* and *Huangpu* Districts. These two districts are not included in the main analysis.

sample from each neighborhood committee in Shanghai. In our data set we have 222,227 individuals comprising 119,081 households.[21] From this data set, we construct neighborhood-level variables that characterize the educational, occupational, and demographic compositions of the neighborhood committees in our sample.[22] As shown in Panel A of Table 1, on average, 48 percent of the households in each neighborhood committee have a college graduate, 86 percent have a registered *hukou* resident of Shanghai, 14 percent have a child younger than 11, and 20 percent have a family member in a high-income occupation (i.e., a professional or technical job).[23] We also construct measures of housing quality. On average, 81 percent of the housing units are owner-occupied, and 30 percent were built after 2000. The average number of rooms per housing unit is 2.2, and the average monthly rent of a housing unit in 2010 was 1,362 RMB.

4.3 Primary school data

4.3.1 Public school attendance zone

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[21] According to the 2010 Chinese Census, 9.4 percent of Shanghai residents lived in collective housing (e.g., dormitories), and the remaining 90.6 percent lived in family households. When calculating the neighborhood characteristics, we exclude the residents living in collective housing.

[22] About 10 percent of Chinese households filled out the long-form questionnaire of the Sixth National Population Survey conducted by the National Bureau of Statistics in November 2010. The 2010 Chinese Census provides a wide range of economic and demographic data, including each household member's relation to the household head, age, educational attainment, occupation, migration history, marriage status, etc. In addition, the data contains variables that characterize each household's residence: whether the unit is rented, its floor area, its number of rooms, age of the building, whether the unit has an independent kitchen, whether the unit has an independent bathroom, etc.

[23] Income data is unavailable in the 2010 census. We use the mini census conducted in 2005 to show that, among all one-digit occupations, professionals and technicians have the highest average monthly salary incomes.

In 2016, Shanghai had 16 urban administrative districts, eight in the central city proper ("core urban districts") and eight in the surrounding suburban areas ("suburban districts").[24] Every April, each urban district's education bureau announces the attendance zones of the public primary schools within its jurisdiction for the next academic year. For five core urban districts and two suburban districts, we can link each RDP to a single school.[25] There are 473 public primary schools in these seven districts. Based on the information from the websites of the district education bureaus, we draw the attendance zone of each public primary school in the seven districts. A school district contains, on average, seven neighborhood committees. Figure 2 shows the typical layout of a school-attendance zone in Pudong District. In most cases, primary school zones are contiguous. Figure 3 shows the attendance zones of two adjacent schools. The thick lines represent the boundaries, and the circles represent transactions in our sample. We link each housing transaction to the nearest boundary. The average distance between a housing unit and the nearest boundary is 196 meters. About 75 percent of the houses are less than 250 meters from their respective boundaries. The regression analysis involves 280 schools and 287 boundaries.[26] All of these boundaries remained unchanged during our study period.

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[24] The eight core urban districts are *Huangpu*, *Pudong, Xuhui, Changning, Jing'an, Putuo, Hongkou,* and *Yangpu*. The eight suburban districts are *Minghang, Baoshan, Jiading, Jinshan, Songjiang, Qingpu, Fengxian*, and *Chongming*.

[25] These seven districts are *Pudong, Changning, Jing'an, Putuo, Yangpu, Minghang*, and *Baoshan*, which had a combined population of 14 million in 2015. (*Zhaibei* District was merged into *Jing'an* District in November 2015.) In three core urban districts, *Hongkou, Huangpu,* and *Xuhui*, some RDPs were assigned to multiple schools. Hence, we cannot identify the school-attendance zones in these districts.

[26] A total of 193 schools were dropped because there were no housing transactions in their attendance zones in our sample, or because the information on the RDPs or neighborhood committees of the transactions was missing, or because some of their zone boundaries were adjusted during our study period.

Our regression sample excludes three core urban districts in the city-center area: *Xuhui* District, *Huangpu* District, and *Hongkou* District. In these districts, some RDPs were assigned to multiple schools. Hence, we are unable to fully identify the school-attendance zones in these districts. We do, however, have some partial information about zone boundary changes (as a result of brownfield redevelopment) in these districts. In Section 6, we use one such boundary change to provide additional evidence.

4.3.2 School-quality measures

Historical magnet schools

We obtained the list of historical magnet schools from the city's education bureau.[27] Among the 473 public primary schools in our sample, 72 are historical magnet schools, and 51 of the 280 public primary schools used in the regression analysis are historical magnet schools.

School input measures

For a subsample of schools, we obtain data on the total enrollment, student-to-teacher ratio and the percentage of senior teachers as of the academic year 2015-2016 from the official websites of the district education bureaus.[28]

Tournament performance

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[27] We thank Muyang Zhang, Jie Chen, and Wei Shi for sharing the magnet-school list with us.

[28] In China, primary-school teacher qualifications are measured by rank in an official five-level system. A senior teacher has a rank of III or higher. A higher rank is associated with longer teaching experience.

We obtain the results of 11 major tournaments in the subjects of mathematics, English, and Chinese from two popular parental websites (www.jzb.com and www.aoshu.com). Detailed information about the tournaments is provided in Table A1 in the appendix. Eight of the tournaments have four prize levels, and the other three have three prize levels. We assign four points to the top prize, three points to the second prize, and so on. The tournament score of a school is the sum of the points won by its students. The distribution of the tournament performance is highly skewed. Half of the schools have zero points. Since participation is voluntary, students in lesser schools may have chosen not to compete.[29] Five schools have scores greater than 200. Figure 4 plots the distribution of the tournament performance for the schools having a score greater than zero and less than 200. In the subsample of the schools for which we have enrollment and input data, we find that a school's tournament score is positively correlated with its total enrollment and magnet-school status, and negatively associated with its student-to-teacher ratio and the percentage of senior teachers.[30]

For our main analysis, we divide the schools into four categories on the basis of tournament performance: the bottom half (those with a score of zero), the lower-middle group between the 50th and 75th percentiles (those with scores between 1 and 9), the upper-middle

[29] Official data on the total number of participants for each tournament is not available. Given that the prize-winning rates for mathematics tournaments are generally around 20 percent, and given the number of prizes for the mathematics tournaments reported in Table A1, we calculate the total number of math-tournament participants in Shanghai to be around 20,000 in 2015. According to the Education Committee of Shanghai, in 2015 there were 76,500 pupils in the 5th grade. Given that students in the schools of the bottom half often choose not to compete in any tournaments, a rough estimation suggests that the average participation rate among students in the schools of the upper half may be close to 50 percent.

[30] We run a Tobit regression of each school's tournament record on the school's total enrollment (in log), magnet-school status, student-to-teacher ratio, and percentage of senior teachers. We also run a linear regression of each school's tournament record on the other school characteristics for a subsample of schools with a positive score. Table A2 reports the results.

group between the 75th and 90th percentiles (those with scores between 10 and 57), and the superstars in the top 10 percent of the distribution (those with scores between 58 and 888).

For the 280 schools used in our regression analysis, Figure 5 plots separately the tournament performance for superstars and non-superstars against the distance to the city center. Most of the schools are located within a 20-kilometer radius of the city center. On average, tournament superstars are closer to the city center than non-superstars. The hollow triangles represent the historical magnet schools. While historical magnet schools have better tournament performance on average, not all perform well.

Panel B of Table 1 reports the summary statistics of the 473 public primary schools in the full sample and the 280 schools in the regression sample. On average, schools in the regression sample have better tournament performance and are more likely to be historical magnet schools.

4.4 Raw data plots

Figure 6 plots discontinuities in tournament performance and housing prices at zone boundaries. Each point represents the conditional average of the variable in question within a given bin of distance to the boundary. Negative distances are on the side of the school with worse tournament performance (Panels A and B), the school that is not a tournament superstar (Panel C), and the school that is not a historical magnet school (Panel D). Panel A shows a large discontinuity in the tournament performance at the boundary. The average gap is about 30 points. Panel B exhibits a noticeable discontinuity in housing prices of about 2,000 yuan per square meter. The discontinuity in housing prices is particularly large at borders between tournament superstars and non-superstars (Panel C). The average price gap is about 5,000 yuan per square meter. The price gap between magnet schools and non-magnet schools is smaller (Panel D).

Table 2 shows that the average rent is higher on the better-school side, which also has a slightly higher percentage of households with members that have a college degree, a local *hukou*, a school-aged child, work in a high-income occupation, and own their current residences. The differences diminish, however, as the sample is further restricted to housing units closer to the zone boundary. For housing units within the 150-meter bin of distance to the boundary, the *t*-statistics of all mean tests are small. Figure 7 shows that all observed physical or socio-economic characteristics of the neighborhoods, including average rents, change continuously at zone boundaries. The lack of discontinuity in any of the demographic or socio-economic characteristics is in contrast to the case of the U.S. where income, education and racial compositions are found to change discontinuously at school-zone boundaries (Kane et al., 2006; Bayer et al., 2007). This suggests that, in China, preferences for better schools are not strongly correlated with income or profession. There is evidence that some Chinese households choose to own a small apartment in a desirable school zone but live in a bigger apartment outside of the zone (Lu, Sun, and Zheng, 2017). Some households may also own properties in the zone of a good school for investment purposes.[31]

5. Results

Four school-quality variables are used in the baseline empirical analysis: three dummy variables corresponding to tournament superstars, upper- and lower-middle performing schools, and a dummy variable for historical magnet schools. The base group includes schools that were not magnet schools and that were in the bottom half in terms of tournament performance.

[31] Using a sample of urban households in 19 major Chinese cities, Cao, Chen and Zhang (2018) show that nearly 20 percent of homeowners possess extra house properties. The decision to do this is largely driven by investment demand.

5.1 The naïve and boundary-fixed-effect models

Columns 1—3 of Table 3 report the estimates of the naïve model (1). Standard errors are clustered at the school-attendance-zone level. Column 1 does not control for housing or neighborhood characteristics. Column 2 adds housing characteristics. Column 3 further controls for neighborhood characteristics at both the RDP level and the neighborhood-committee level. As shown in column 1, the effect of tournament performance is very large: relative to schools in the base group, the average housing prices are 24 percent higher for tournament superstars, 12 percent higher for schools in the upper-middle group, and seven percent higher for schools in the lower-middle group. After controlling for tournament performance, the premium for former magnet schools is 8.6 percent but statistically insignificant. The estimated coefficients of the school-quality variables decline slightly when more controls are included. This implies that high-performing public primary schools in Shanghai tend to be located in more attractive neighborhoods. We report the estimates of the hedonic coefficients on two typical neighborhood characteristics: the RDP's property management fee, and the neighborhood committee's percentage of households with a college graduate. Column 3 shows that they are all positively correlated with housing price.

Columns 4—8 report the results of the boundary-fixed-effect model (2). Column 4 uses the full sample, while columns 5—8 are restricted to housing units located closer to the zone boundary. The inclusion of boundary fixed effects reduces the estimates of the tournament performance dummies significantly. The estimates from the sample of housing sales less than 150 meters from the boundary indicate that the premium for a tournament superstar is 14.3 percent (column 8), or about 438,000 RMB (66,000 USD, using the exchange rate in June 2016). (The average house price was 37,822 yuan per square meter and the average usable floor area of a housing unit was 81 square meters).

Table A3 in the appendix reports the results of the boundary-fixed models corresponding to columns 4—8 of Table 3, which exclude all neighborhood controls (physical and socio-economic characteristics). The estimates remain robust, which further supports the identification assumption that the neighborhood characteristics are uncorrelated with school quality at zone boundaries.

5.2 The cross-boundary differential model

Table 4 reports the results of the cross-boundary differential model. The cross-boundary difference in housing prices is calculated using the residuals from a hedonic housing-price regression on a vector of housing and neighborhood characteristics.[32] All regressions are weighted by the inverse of the distance between the actual sale and control sale. All regressions include a quadratic polynomial of the distance between the actual sale and the corresponding school boundary.[33] Standard errors are clustered at the school-boundary level.

Column 1 uses the full sample. Columns 2—4 are based on different samples of house

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[32] These characteristics include the log of the internal floor area, dummy variables for building height (short, middle, tall), floor level, interactions of building-height dummies and floor level, dummies for internal condition (raw, simple, fair, delicate, luxury), and dummies indicating the number of bedrooms (one, two, or more), RDP's FAR, green-space ratio, monthly property management fee, age of the building and its squared term, and neighborhood committee's percentages of households with members that have a college degree, a local *hukou*, a school-aged child (aged 0-11), work in a high-income occupation, and own their current residences. In the hedonic regression, all these characteristics are further interacted with urban district dummies to control for any potential heterogeneous effects across space.

[33] Our main results remain unchanged if we add a linear or cubic polynomial of the distance between the actual sale and the closest school boundary.

sales, ranging from those less than 250 meters from the boundary to those less than 150 meters from it. The estimates are fairly stable across distance bins. This is not surprising, as the cross-boundary differential model has already accounted for the distance between house sales on opposite sides of the boundaries. Let us focus on the results from the sample of the narrowest distance bin (columns 4 and 5). Relative to the base group, the average housing price in the attendance zone of a tournament superstar is about 14 percent higher, or about 430,000 RMB higher (65,000 USD, using the exchange rate in June 2016). Housing units in the attendance zone of an upper-middle performing school have a marginally significant premium of 5 percent. The premium for the lower-middle group is small and insignificant. These results are largely consistent with the results of the boundary-fixed-effect model (see column 8 of Table 3). This indicates that long boundaries may not be a serious concern. Finally, the coefficient of the magnet-school dummy is small and insignificant after controlling for tournament performance.

5.3 Unobserved neighborhood characteristics

We conduct several robustness checks to see whether the results reported in Table 4 are driven by discontinuities in unobserved neighborhood characteristics at zone boundaries.

5.3.1 Cross-boundary rental value difference

Due to their low priority in the admissions system, renters in China typically cannot send their children to a public primary school that is in high demand. Hence, rental values should not jump at zone boundaries unless there are discontinuities in neighborhood characteristics (observed and unobserved) other than school quality. To each housing unit in our sample we assign the average monthly rent in the neighborhood committee where it is located. We then run the cross-boundary differential regression with the cross-boundary difference in the log average monthly rent being the explained variable. Column 1 of Table 5 shows that tournament performance has no effect on rents.[34]

5.3.2 Exclude significant geographic obstacles

Discontinuity in price at a zone boundary may be caused by geographic features that coincide with the boundary. To address this concern, we eliminate boundaries that coincide with main roads, elevated highways, and rivers. As shown in column 2 of Table 5, the main results remain robust.

5.3.3 Control for the cross-boundary differential in private school quality

The quality of private primary schools in Shanghai varies greatly, and the better ones tend to be located in richer neighborhoods. (Table A5 in the appendix presents summary statistics of 90 private primary schools.) We construct an index of private-school quality for each housing unit in our sample. For each housing unit *i*, we calculate the distance, denoted by d_{ik}, between house *i* and each private school *k* that admits students living in the neighborhood of house *i*. The private-school quality index for house *i* is defined as:

$$private_i = \sum_k \frac{\frac{1}{d_{ik}}}{\sum_k \frac{1}{d_{ik}}} \text{tournament performance}_k \ . \qquad (5)$$

[34] An underlying assumption of this test is that renters and homeowners have similar preferences for neighborhood amenities. To provide supportive evidence for this assumption, we regress the housing and rental prices on the same set of neighborhood amenities. As shown in Table A4, the signs of the coefficients on the neighborhood amenities are generally similar between renters and homeowners.

As shown in Table A6 in the appendix, private-school quality is higher for housing units located in RDPs with lower density, more green space, and higher property management fees. In addition, good private schools tend to be closer to the city center. These correlations suggest that the private-school quality index may be correlated with unobserved neighborhood amenities in the error term. Column 3 of Table 5 shows that the main results remain unchanged after controlling for this private-school quality measure.

5.4 Other robustness checks

5.4.1 Other school-quality variables

One concern is that our tournament measure may not fully capture the school attributes valued by parents. As discussed in Hanushek (2006) and Todd and Wolpin (2003), student performance is a function of various inputs, including family characteristics, student ability, and additional learning that the school contributes.[35] We find three school-input variables: total

[35] There is a body of literature that has attempted to disentangle the independent influences of various inputs, such as the quantity of school resources and student peer quality. Using data from Chicago for 1987—1991, Downes and Zabel (2002) find that test scores are capitalized into local real estate prices, whereas school expenditure measures are not. Using detailed housing price and school data from London and southeast England, Gibbons and Machin (2006) find that housing prices increase with the popularity of nearby schools and with the degree of congestion, which may signal the school's consumption benefits (e.g., safety, physical attributes, or ethos). Cellini et al. (2010) use referenda outcomes in California's school finance system to estimate the effect of infrastructure spending on the housing market. They find that housing prices respond to the level of capital expenditure per pupil. Neilson and Zimmerman (2014), focusing on the public school system in New Haven, Connecticut, find that investment in school infrastructure raised home prices in affected neighborhoods. Using detailed test score data from primary school students in different grades in England, Gibbons et al. (2013) show that both peer effects and a school's added value raise housing prices. Using data from Atlanta, Georgia, Andreyeva and Patrick (2017) find that better access to charter schools significantly increases housing prices.

enrollment, student-to-teacher ratio and the percentage of senior teachers. As shown in column 4 of Table 5, controlling for these variables in the cross-boundary differential specification does not change the results significantly. After controlling for the main school-quality variables, the three input variables have no effect on housing price.

5.4.2 Exclude suburban sample

In suburban areas, attendance-zone boundaries are sometimes adjusted when new schools are opened. When households perceive that school quality may change over time, the static hedonic valuation method may be biased (Bishop and Murphy, 2017). To alleviate this concern, we exclude the sample in the suburban area near the city fringe of Shanghai. Column 5 of Table 5 shows that the main results remain robust.

5.4.3 Alternative tournament performance measures

We replace the three tournament category variables with a standardized tournament score variable having a standard deviation of one. Column 1 of Table 6a shows that a one-standard-deviation increase in tournament performance raises housing prices by 2.4 percent, which is in line with the existing estimates found in the international literature that uses test scores to measure school quality (Black and Machin, 2011; Nguyen-Hoang and Yinger, 2011). In columns 2 and 3, we estimate a quadratic and cubic function of the standardized tournament score. The results suggest that the price effect is highly nonlinear in tournament performance.

Of the schools in our sample, 14 percent have at least one first prize. Column 1 of Table 6b shows that the effect of having a top prize is small and insignificant. In column 2 of Table 6b, we replace the baseline tournament variables with four dummy variables indicating whether the school lies above the 90th percentile in the distribution of the total points by subject. The results suggest that math and comprehensive tournaments matter more than others. We use principal factor analysis (Anderson and Rubin, 1956) to construct a latent school-quality variable from the performance in math and comprehensive tournaments. We define three tournament performance dummies based on this latent variable and re-run regression (4). Column 3 of Table 6b reports the results. The superstar price premium is 17.2 percent, which is slightly larger than the result from the main analysis in Table 4.

5.4.4 Alternative cutoff percentiles

Lowering the cutoff percentile increases the number of schools in the superstar category and may reduce the price gap between the schools in the superstar category and those in the base group. Table A7 reports the regression results for various superstar cutoff percentiles based on tournament scores. The size of the estimate of the superstar price premium becomes smaller as we lower the cutoff percentile.

5.4.5 Alternative matching method

For the full sample, the average of the distance between the actual sale and control sale is 679 meters, and its standard deviation is 446 meters. As a robustness check, for the construction of the control sale, we use only properties on the opposite side of the boundary that are located within a 1-km ring around the actual sale. As reported in Table A8 of the appendix, the main results remain robust.

6. Evidence from boundary adjustment

Zone boundaries in the city-center area are adjusted occasionally to accommodate changing demographics resulting from brownfield redevelopment. Such redevelopment generally causes local residents to move away when their houses are torn down for new commercial developments. When a neighborhood committee loses a majority of its residential population, the district government considers merging it into another neighborhood committee to reduce administrative costs. In some cases, this may cause the corresponding school boundaries to change. Brownfield redevelopment in Shanghai usually requires real estate developers to pay extremely high compensation fees, so such school-zone adjustments do not occur often.

Zone-boundary adjustments are hard to predict beforehand and are only announced shortly before they take place. They thus offer an ideal opportunity to disentangle the confounding effects of unobserved neighborhood characteristics. We find one instance of boundary adjustment during our study period. On April 1, 2016, the education bureau of *Xuhui* District announced that for the next academic year, children from two RDPs (*Baoli Xi'an* and *Shengda Huayuan*) would be assigned to *Longhua* Primary School (having a tournament score of zero) rather than *Donger* Primary School, a tournament superstar (having a tournament score of 79).

We use a DID strategy to estimate the price effect of this change. We select as the control group nine RDPs located within a 3-km radius of the treated RDPs (*Baoli Xi'an* and *Shengda Huayuan*) that were not affected by any boundary adjustments between May 2015 and December 2016. The geographic proximity of the treated group and control group makes both groups likely to share a common pre-existing price trend.

The dependent variable in our analysis is the log monthly average per-square-meter price of each RDP between May 2015 and December 2016 as provided by the *China Index*

Academy.[36] The unit of observation in this case is a single RDP in a single month. We first use the following model to explore the dynamic effect of the boundary change:

$$\log p_{r,t} = \sum_{l=-10}^{8} \phi_l Treat_r \times Month_t^l + \eta_r + \kappa_t + u_{r,t}\,, \qquad (6)$$

In the model above, $p_{r,t}$ is the average per-square-meter price of RDP *r* in month *t*, $Treat_r$ is a dummy variable indicating whether RDP *r* is treated, $Month_t^l$ is a month dummy ($l = 0$ is the month of April 2016), η_r represents the RDP fixed effects, κ_t represents the month fixed effects, and $u_{r,t}$ is an error term. Figure 8 plots the estimates of ϕ_l and the 95-percent confidence intervals. May 2015 is the omitted category. Prior to the announcement of the boundary change, both the treatment and control groups shared the same price trend. But immediately after the announcement, the average price of the treated RDPs declined by 10 percent relative to the control group. The average price effect was between –10 percent and –20 percent from May 2016 to December 2016.

We then use the following DID specification to estimate the average effect of the school-boundary adjustment over the post period:

$$\log p_{r,t} = \phi Treat_r \times Post_t + \eta_r + \kappa_t + u_{r,t}\,, \qquad (7)$$

where $Post_t$ is a dummy variable that indicates the post-treatment period, i.e., $Post_t$ equals one for *t* after April 2016. Table 7 reports the estimates. On average, housing units in the attendance zone of a tournament superstar are 13 percent higher than comparable housing units in the attendance zone of a school in the bottom half, which is similar to the estimate in the cross-sectional analysis. One thing to note is that, considering that households may worry about whether the adjustment is permanent, the DID estimate is likely to be biased downward.

[36] We do not have enough observations to conduct an analysis using individual transactions.

7. Conclusion

We study the spatial allocation of educational resources and its effect on the housing market in urban China. Our objective is to provide an estimate of the school-quality premium based on the best available data. We apply the boundary-fixed-effect model of Black (1999) and the cross-boundary differential model of Fack and Grenet (2010) to control for unobserved neighborhood characteristics that vary continuously at zone borders. We also take advantage of a change in zone boundary to provide a separate DID estimate for the quality premium. The cross-sectional and panel-data analyses consistently show that the premium for a tournament superstar is between 13 percent and 15 percent of the house price, which is equivalent to about 400,000 RMB. This premium is large, roughly equal to five years of private schooling fees.[37]

The high premium for a small group of superstar schools is perhaps a consequence of the winner-take-all nature of the Chinese educational system. After middle school, the best students are sorted into a small number of magnet high schools, which in turn send a high fraction of their graduates to the most prestigious universities in the country. In recent years, the Chinese government has adopted policies that seek to make compulsory education more equitable and less examination-oriented. Nevertheless, in the minds of many anxious parents, it will be hard for their children to catch up if they fall behind in primary school.

The large premium for superstar schools indicates that, although public primary schools in Shanghai are supposed to be equally funded, many parents believe that studying in a

[37] A selective private primary school in Shanghai usually costs more than 70,000 yuan per academic year. See http://www.i-bei.com/shanghai/sxzx/xx/2016/0218/26824.html.

superstar school can significantly improve the prospects of their children. Is this perceived advantage real? Are superstar primary schools better at sending their students to the top middle schools? And do they improve the long-term academic performance of their students? These are important questions for future research.

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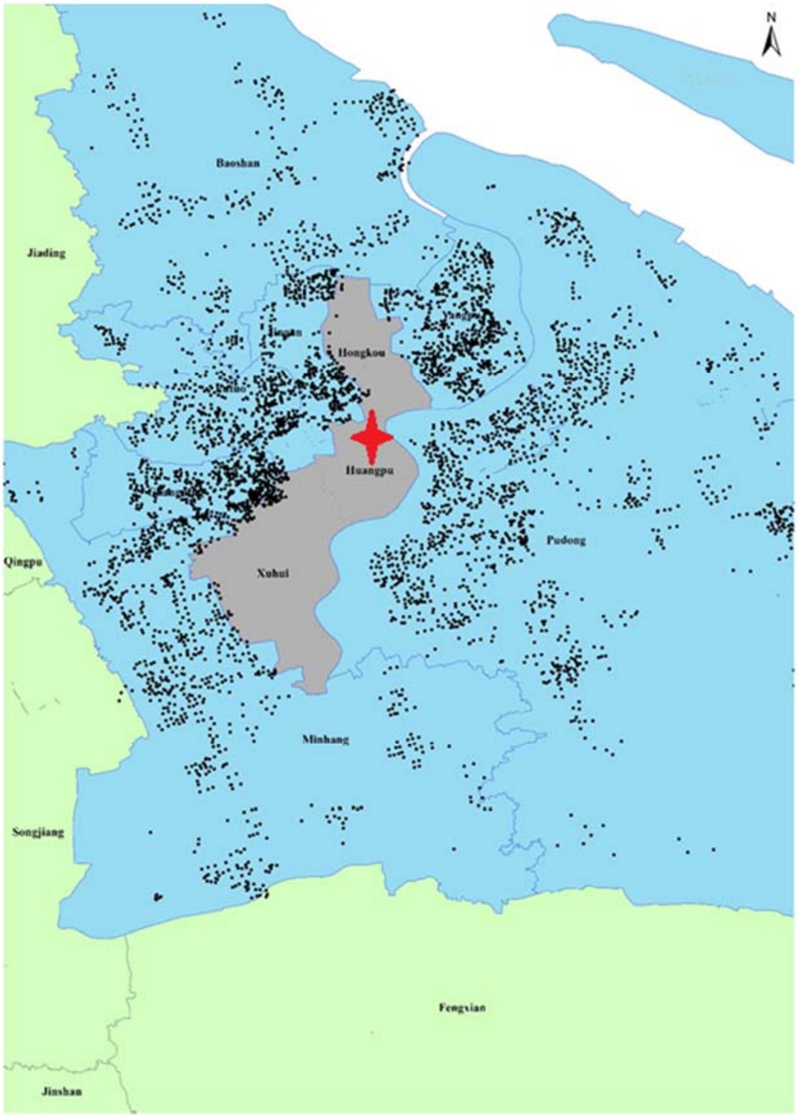
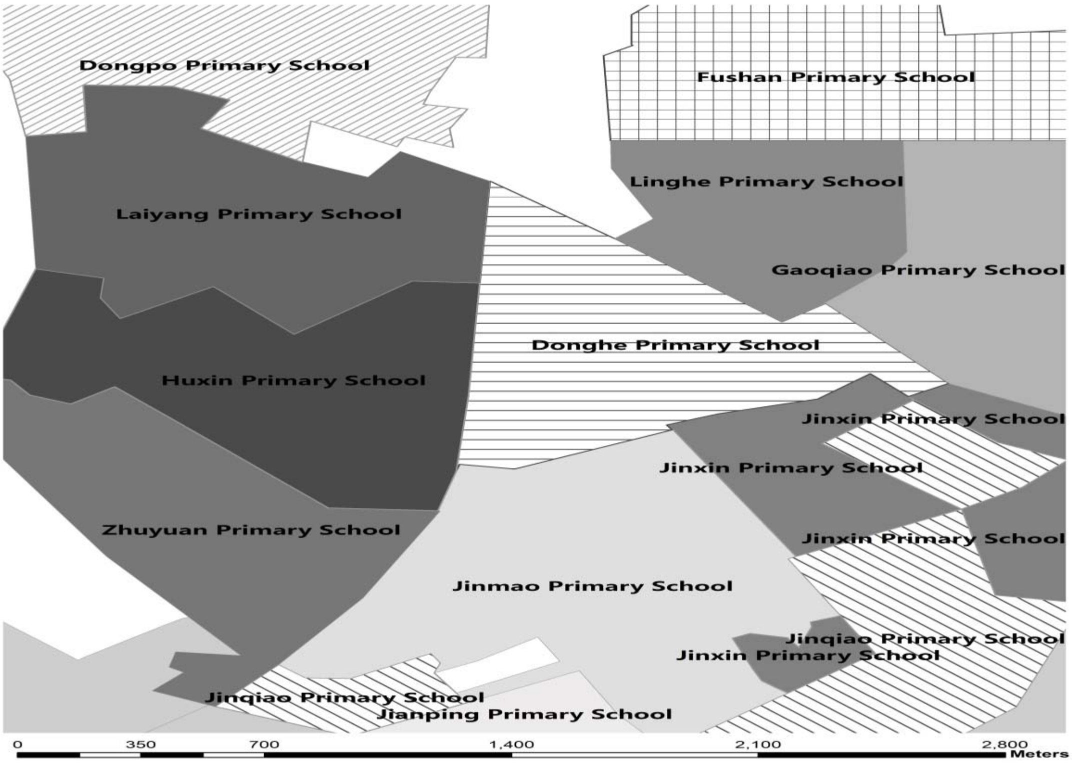
Figure 1: Map of the housing transaction sample



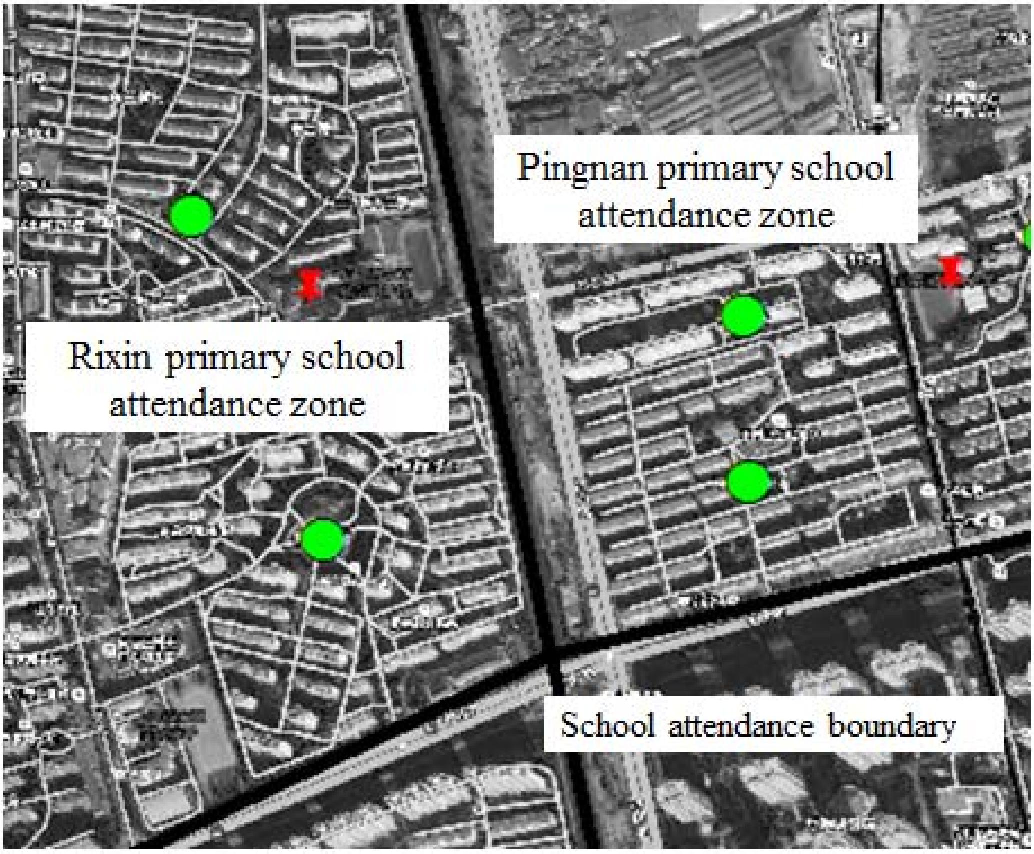
Notes: Each dot in the graph represents a housing unit in our sample. The star indicates the city center of Shanghai.

Figure 2: School-attendance zones in *Pudong* District, Shanghai



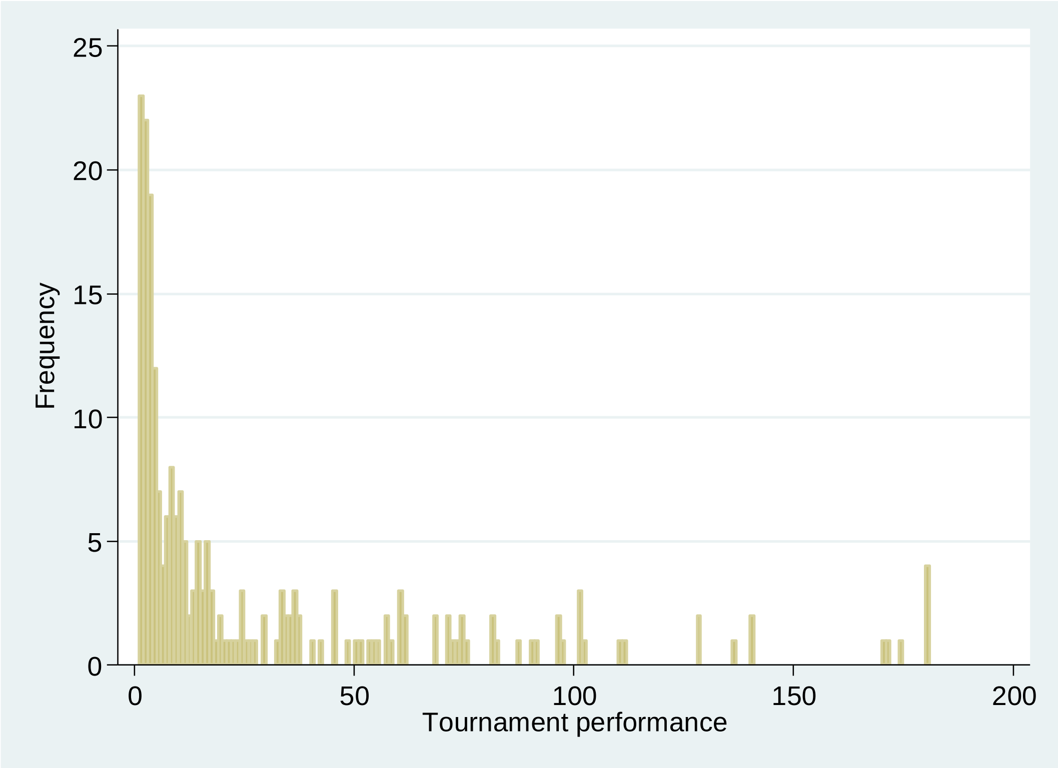
Notes: Each differently shaded region in this graph represents one school-attendance zone.

Figure 3: School-attendance boundary



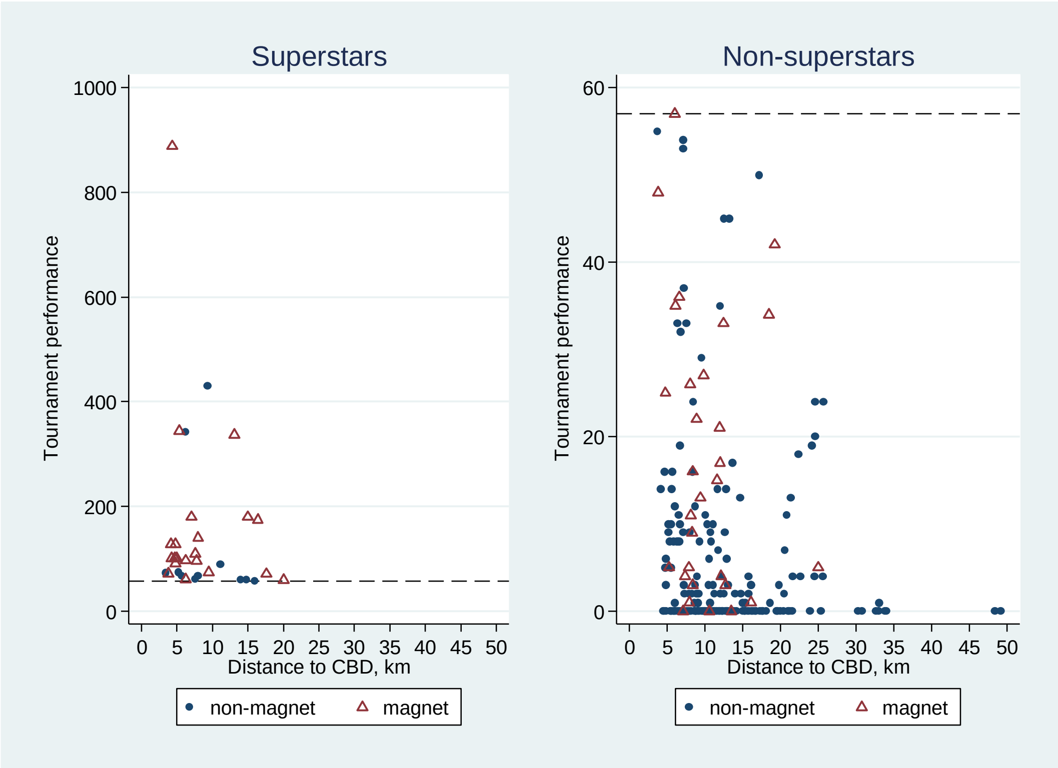
Notes: The thick lines represent the school-attendance boundaries, and the circles represent transactions in our sample.

Figure 4: Tournament performance distribution



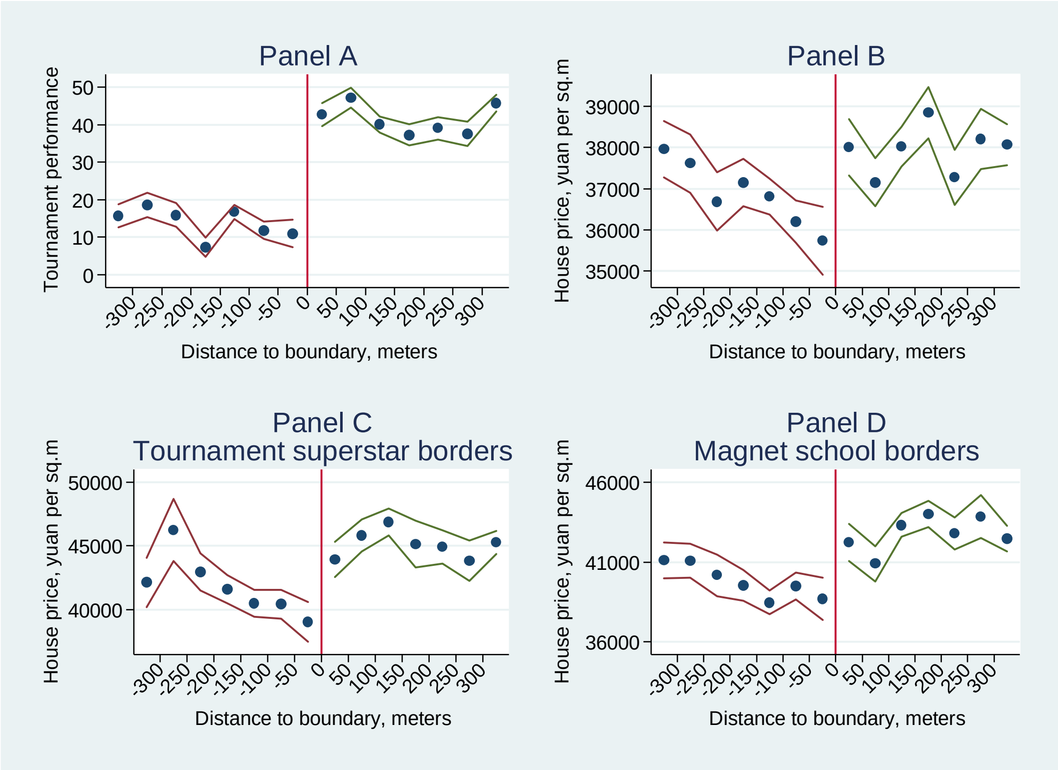
Notes: For presentation purposes, we exclude 245 schools that have tournament scores of zero and 5 schools with tournament scores above 200.

Figure 5: Tournament performance, historical magnet-school status, and distance to city center



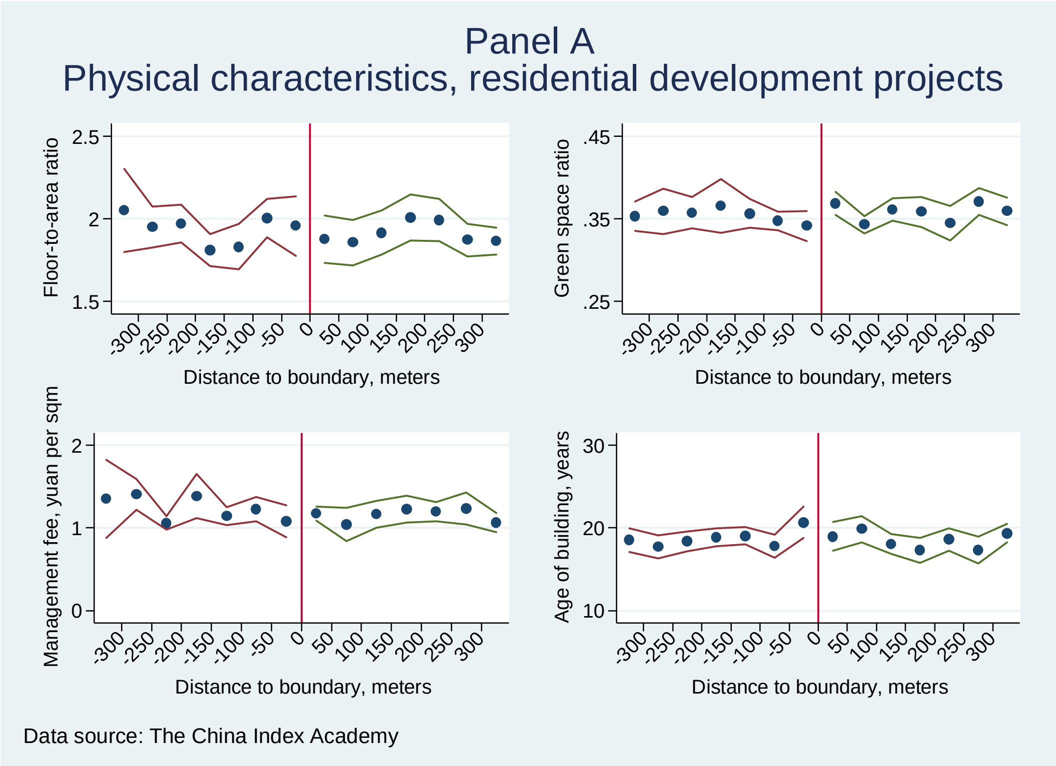
Notes: Each dot or hollow triangle in the graph represents a public primary school in our sample. The hollow triangles represent the historical magnet schools. The dashed horizontal line in each chart corresponds to the tournament performance score of 57.

Figure 6: Tournament performance and housing prices around the zone boundary



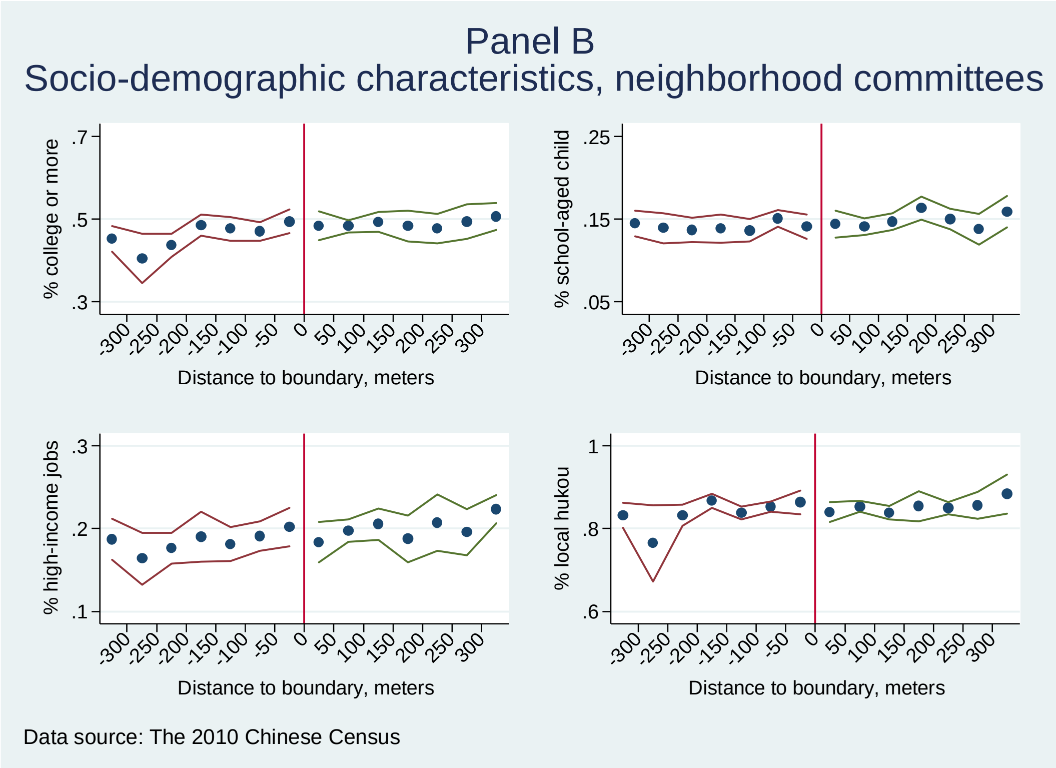
Notes: Each panel is constructed using the following procedure: (i) regress the variable in question on boundary fixed effects and on 50-meter band distance to the boundary dummy variables; (ii) plot the coefficients on these distance dummies and their 95% confidence intervals. As such, a given point in each panel represents this conditional average within a given bin of distance to the boundary. In Panels A and B, negative distances indicate the lower tournament performance side. In Panels C and D, negative distances indicate the non-superstar and the non-magnet-school sides, respectively. Note that for the housing price regression, we also control for the characteristics of housing units.

Figure 7: Neighborhood physical and socio-demographic characteristics around the zone boundary



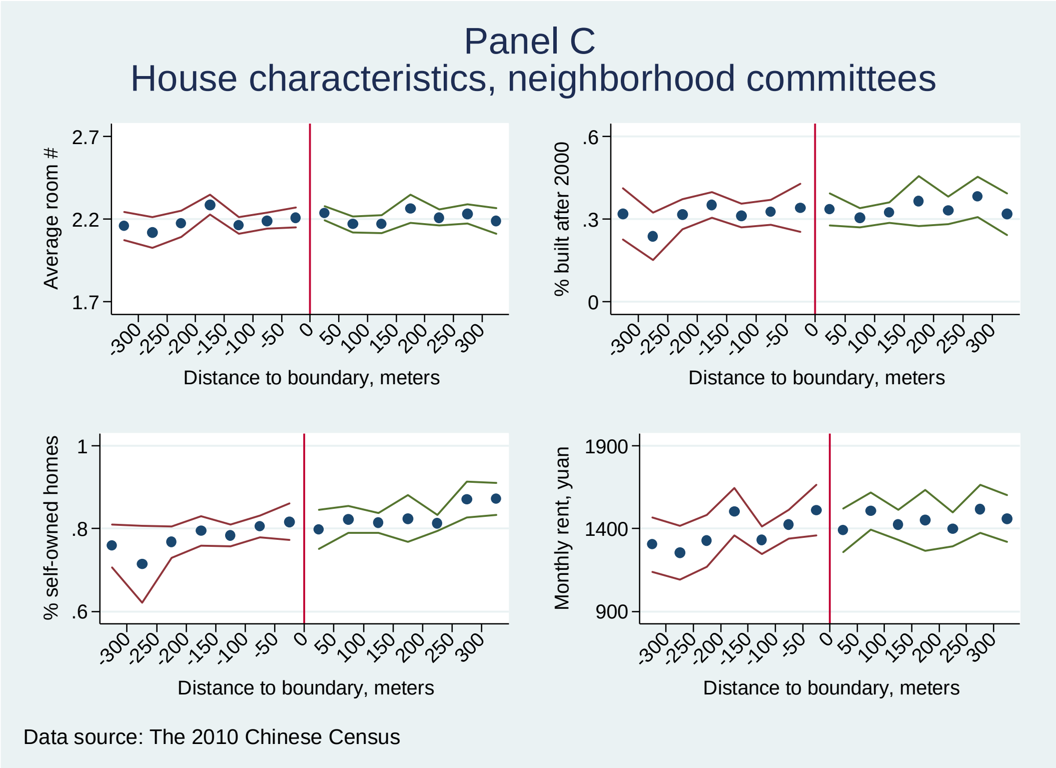
Notes: Each panel is constructed using the following procedure: (i) regress the variable in question on boundary fixed effects and on 50-meter band distance to the boundary dummy variables (regressions are weighted by the number of house sales in each RDP); (ii) plot the coefficients on these distance dummies and their 95% confidence intervals. As such, a given point in each panel represents this conditional average within a given bin of distance to the boundary. A negative distance indicates the lower tournament performance side.

Figure 7: Neighborhood physical and socio-demographic characteristics around the zone boundary (cont'd)



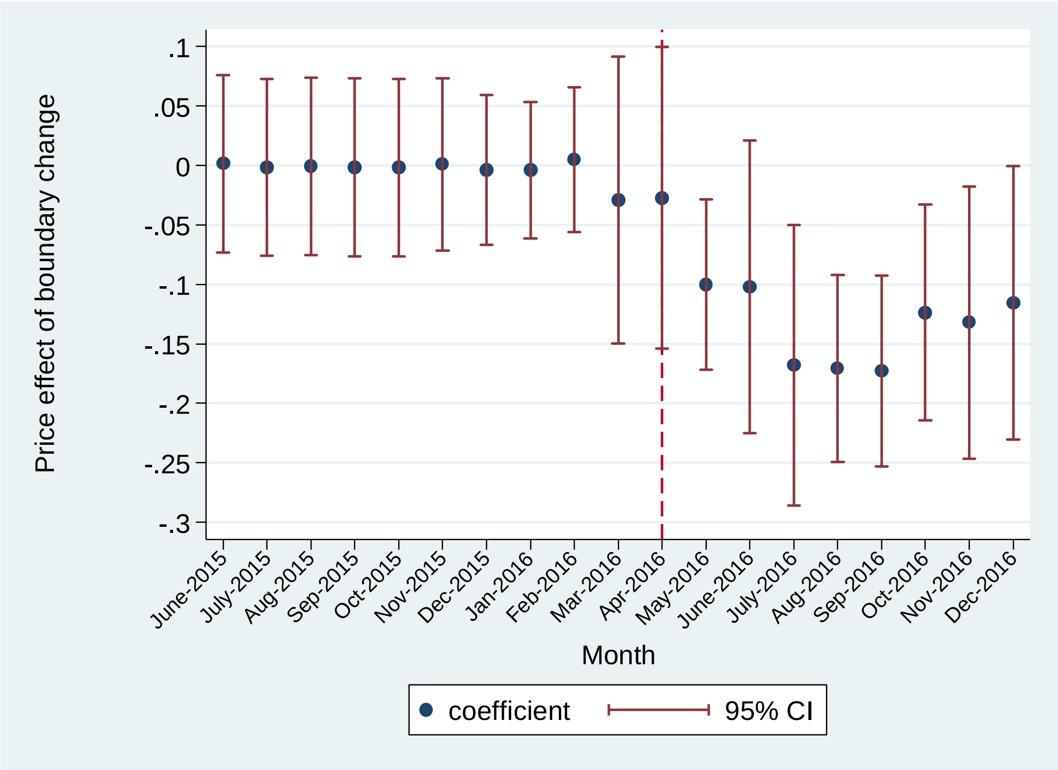
Notes: Each panel is constructed using the following procedure: (i) regress the variable in question on boundary fixed effects and on 50-meter band distance to the boundary dummy variables (regressions are weighted by the number of house sales in each neighborhood committee); (ii) plot the coefficients on these distance dummies and their 95% confidence intervals. As such, a given point in each panel represents this conditional average within a given bin of distance to the boundary. A negative distance indicates the lower tournament performance side.

Figure 7: Neighborhood physical and socio-demographic characteristics around the zone boundary (cont'd)



Notes: See Panel B of Figure 7 for notes.

Figure 8: Dynamic effect of a school boundary adjustment



Notes: This graph plots the estimates of coefficient ϕ_l in regression model (6) and the corresponding 95% confidence intervals. The dashed line indicates the month when the boundary adjustment was announced. May 2015 is the omitted category.

Table 1 Panel A: Summary statistics of housing transactions, residential development projects, and neighborhood committees

Distance from boundary	All sales		<250 meters		<200 meters		<150 meters	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
House transactions								
House price (yuan in 2016 per sq.m)	37,822.39	13,150.22	38,601.50	13,403.74	38,729.33	13,457.68	38,265.69	12,624.13
ln (house price)	10.48	0.36	10.50	0.35	10.50	0.35	10.50	0.34
Total price (10,000 yuan)	318.91	251.46	320.94	266.80	323.86	275.11	304.61	253.63
Internal floor area (sq. meters)	80.52	42.20	78.65	43.58	78.89	44.53	75.62	42.04
Number of bedrooms	1.97	0.82	1.92	0.81	1.92	0.81	1.88	0.80
Internal condition (finished or not)	0.51	0.50	0.49	0.50	0.49	0.50	0.47	0.50
Floor level	10.53	8.65	10.74	9.20	11.01	9.58	10.26	7.96
Observations	10,472		7,796		6,618		5,184	
Residential development projects								
Floor-to-area ratio	1.92	0.77	1.96	0.79	1.96	0.79	1.98	0.78
Green-space ratio	0.35	0.09	0.34	0.08	0.34	0.08	0.34	0.08
Monthly management fee (yuan per sq.m)	1.15	0.94	1.13	0.95	1.16	0.99	1.15	0.97
Building age (year)	19.39	10.69	19.89	10.75	19.86	10.46	20.28	10.99
Distance to city center (km)	10.62	6.11	10.11	5.59	10.04	5.63	9.69	4.94
Subway stop within a 1.2-km ring	0.83	0.37	0.85	0.36	0.87	0.34	0.88	0.33
Observations	1,667		1,316		1,130		921	
Neighborhood committees (Census 2010)								
% households with a college graduate	0.48	0.18	0.48	0.18	0.48	0.18	0.48	0.17
% households with a local *hukou*	0.86	0.14	0.87	0.14	0.87	0.14	0.87	0.13
% households with a child younger than 11	0.14	0.09	0.13	0.09	0.13	0.09	0.13	0.08
% households with a high-income occupation	0.20	0.11	0.20	0.11	0.20	0.11	0.20	0.11
% housing units are self-owned	0.81	0.18	0.81	0.18	0.81	0.18	0.81	0.18
Avg. number of rooms of a housing unit	2.18	0.45	2.14	0.46	2.14	0.46	2.12	0.46
% housing units built after 2000	0.30	0.37	0.27	0.36	0.26	0.35	0.24	0.33
Avg. monthly rental price (2010 yuan)	1,361.98	743.07	1,349.25	743.77	1,331.68	749.12	1,338.13	730.18
Observations	760		607		528		395	

Table 1 Panel B: Summary statistics, public primary schools

	All public primary schools (N=473)			Public primary schools for regression analysis (N=280)		
	Mean	S.D.	Obs.	Mean	S.D.	Obs.
Tournament performance	18.92	60.56	473	23.49	73.24	280
Having a historical "Magnet School" title	0.15	0.36	473	0.18	0.39	280
Total enrollment	952.73	792.35	463	1,046.16	874.00	250
Student-to-teacher ratio	13.70	4.62	462	14.15	5.07	250
Percentage of senior teachers	0.57	0.14	429	0.57	0.12	250

Table 2: Comparison of characteristics of neighborhoods located on the better and worse sides of school-zone boundaries

Distance from boundary	All sales		<250 meters		<200 meters		<150 meters	
	Diff. in means	T-statistics	Diff. in means	T-statistics	Diff. in means	T-statistics	Diff. in means	T-statistics
RDP characteristics								
Floor-to-area ratio	-0.015	-0.32	0.064	1.13	0.089	1.51	-0.001	-0.02
Green-space ratio	0.003	0.56	-0.005	-0.72	0.002	0.22	0.005	0.73
Monthly management fee (yuan per sq. m.)	-0.110	-1.57	-0.011	-0.17	-0.022	-0.30	0.007	0.09
Building age (year)	-0.085	-0.18	-0.414	-0.74	-0.717	-1.20	-0.312	-0.38
Neighborhood committee characteristics								
% households with a college graduate	0.033***	2.97	0.013	1.16	0.007	0.61	0.010	0.78
% households with a local *hukou*	0.021*	1.66	-0.000	-0.03	-0.007	-0.81	-0.004	-0.51
% households with a child younger than 11	0.011*	1.89	0.005	0.89	0.001	0.23	-0.004	-0.54
% households with a high-income occupation	0.023**	2.39	0.014	1.20	0.010	0.81	0.010	0.80
% housing units are self-owned	0.065***	3.95	0.027*	1.88	0.022	1.40	0.017	0.94
Avg. number of rooms of a housing unit	0.020	0.87	-0.002	-0.10	-0.002	-0.09	-0.010	-0.34
% housing units built after 2000	0.020	0.91	-0.002	-0.10	0.001	0.04	0.001	0.04
Avg. monthly rent price (2010 yuan)	93.571**	2.17	0.419	0.01	-5.115	-0.10	24.790	0.43

Notes: *** p<0.01, ** p<0.05, * p<0.1. The *t*-statistic is for the null hypothesis that the difference between the means of the better and the worse sides of the boundary (as measured by the tournament performance) is zero. All *t*-statistics are adjusted for clustering at the school-attendance-zone level. Each test is weighted by the number of house sales in the corresponding geographic unit (i.e., RDP or neighborhood committee).

Table 3: Regression results of naïve and boundary-fixed-effect models

Dependent variable: log of price per square meter (in 2016 RMB)								
	All sales	All sales	All sales	All sales	Subsample: within 250 m to border	Subsample: within 200 m to border	Subsample: within 150 m to border	Subsample: within 150 m to border
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dummy: tournament superstar	0.236***	0.210***	0.186***	0.070*	0.071	0.104**	0.122*	0.143***
	(0.088)	(0.070)	(0.064)	(0.039)	(0.044)	(0.049)	(0.063)	(0.042)
Dummy: upper-middle tournament performance	0.119**	0.080*	0.068*	0.007	0.009	-0.000	-0.010	-0.005
	(0.054)	(0.041)	(0.037)	(0.019)	(0.020)	(0.021)	(0.024)	(0.026)
Dummy: lower-middle tournament performance	0.072	0.053	0.034	-0.030*	-0.056***	-0.051***	-0.022	-0.021
	(0.049)	(0.041)	(0.033)	(0.016)	(0.019)	(0.018)	(0.021)	(0.021)
Dummy: former magnet school	0.086	0.054	0.037	0.043	0.069**	0.063*	0.030	
	(0.075)	(0.051)	(0.043)	(0.030)	(0.033)	(0.035)	(0.043)	
RDP's monthly management fee			0.053***	0.039***	0.040**	0.038**	0.043***	0.044***
			(0.011)	(0.011)	(0.016)	(0.017)	(0.016)	(0.016)
NC's % households with a college graduate			0.329***	0.104**	0.157**	0.118*	-0.001	-0.001
			(0.107)	(0.048)	(0.069)	(0.065)	(0.063)	(0.063)
Housing characteristics	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Neighborhood characteristics	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Boundary fixed effects	No	No	No	Yes	Yes	Yes	Yes	Yes
Observations	10,472	10,472	10,472	10,472	7,796	6,618	5,184	5,184
R-squared	0.099	0.332	0.411	0.708	0.709	0.711	0.661	0.661

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$ Standard errors in parentheses are clustered at the school-attendance-zone level. Housing characteristics include the log of internal floor area, dummy variables for building height (short, middle, tall), floor level, interactions of building-height dummies and floor level, dummies for internal condition (raw, simple, fair, delicate, luxury), and dummies indicating number of bedrooms (one, two or more). Neighborhood characteristics include RDP's FAR, green-space ratio, monthly property management fee, and building age and its squared term, and neighborhood committee's percentages of households with members that have a college degree, a local *hukou*, a school-aged child (aged 0-11), work in a high-income occupation, and own their current residences. All regressions control for a quadratic polynomial of the distance between each house sale and the corresponding school boundary.

Table 4: Regression results of the effect of school-quality differentials on cross-boundary housing price differentials

Dependent variable: Cross-boundary differential in the log of housing price (in 2016 RMB)					
	All sales	Subsample: within 250 m to border	Subsample: within 200 m to border	Subsample: within 150 m to border	Subsample: within 150 m to border
	(1)	(2)	(3)	(4)	(5)
Diff. Dummy: tournament superstar	0.114**	0.131***	0.149***	0.139***	0.146***
	(0.046)	(0.049)	(0.053)	(0.050)	(0.035)
Diff. Dummy: upper-middle tournament performance	0.033	0.036	0.038	0.047*	0.050
	(0.022)	(0.025)	(0.025)	(0.027)	(0.030)
Diff. Dummy: lower-middle tournament performance	-0.004	-0.005	-0.002	-0.003	-0.002
	(0.020)	(0.022)	(0.020)	(0.022)	(0.022)
Diff. Dummy: former magnet school	0.031	0.027	0.016	0.008	
	(0.033)	(0.036)	(0.038)	(0.039)	
Observations	10,472	7,796	6,618	5,184	5,184
R-squared	0.054	0.062	0.065	0.056	0.056

Notes: *** p<0.01, ** p<0.05, * p<0.1 Standard errors in parentheses are clustered at the zone-boundary level. Each regression is weighted by the inverse of the distance between the actual sale and control sale. All regressions control for a quadratic polynomial of the distance between the actual sale and the corresponding school boundary.

Table 5: Effect of school-quality differentials on cross-boundary housing price differentials, robustness checks

Distance from boundary: 150 m					
	Cross-border differential in the log of monthly rent	Cross-border differential in the log of housing price			
	(1)	(2)	(3)	(4)	(5)
Diff. Dummy: tournament superstar	-0.015	0.132**	0.134**	0.107*	0.141**
	(0.094)	(0.053)	(0.052)	(0.060)	(0.055)
Diff. Dummy: upper-middle tournament performance	-0.007	0.044	0.047*	0.026	0.062**
	(0.081)	(0.029)	(0.027)	(0.032)	(0.027)
Diff. Dummy: lower-middle tournament performance	0.024	-0.001	-0.005	-0.011	0.000
	(0.075)	(0.023)	(0.022)	(0.026)	(0.023)
Diff. Dummy: former magnet school	-0.031	0.002	0.008	-0.039	0.007
	(0.084)	(0.041)	(0.039)	(0.039)	(0.040)
Diff. private school quality of RDP			0.002		
			(0.002)		
Diff. log total enrollment				0.057	
				(0.037)	
Diff. Student-to-teacher ratio				-0.001	
				(0.004)	
Diff. percentage of senior teachers				0.017	
				(0.134)	
Exclude borders overlapping big roads, elevated highways, rivers		Yes			
Exclude borders located near city fringes					Yes
Observations	4,839	4,687	5,184	4,302	4,901
R-squared	0.032	0.047	0.058	0.062	0.059

Notes: *** p<0.01, ** p<0.05, * p<0.1 Standard errors in parentheses are clustered at the zone-boundary level. Each regression is weighted by the inverse of the distance between the actual sale and control sale. For the regression of column 1, the construction of the "control rent" follows the same approach we used to construct the control sale. All regressions control for a quadratic polynomial of the distance between the actual sale and the corresponding school boundary. In column 5, we exclude the school borders less than 3 km from the district borders between *Baoshan* District and *Jiading* District, between *Minghang* District and *Qingpu* District, between *Minhang* District and *Songjiang* District, and between *Minhang* District and *Fengxian* District.

Table 6a: Effect of school-quality differentials on cross-boundary housing price differentials, alternative tournament performance measures

Dependent variable: Cross-boundary differential in the log of housing price (in 2016 RMB)			
	Subsample: within 150 m to border		
	(1)	(2)	(3)
Diff. Standardized tournament performance (S.D. equals one)	0.024*	0.020	0.079**
	(0.013)	(0.027)	(0.031)
Diff. Quadratic term of standardized tournament performance (S.D. equals one)		0.000	-0.018**
		(0.002)	(0.008)
Diff. Cubic term of standardized tournament performance (S.D. equals one)			0.001**
			(0.000)
Diff. Dummy: former magnet school	0.038	0.042	0.016
	(0.032)	(0.036)	(0.038)
Observations	5,184	5,184	5,184
R-squared	0.046	0.046	0.068

Notes: See Table 4 for notes.

Table 6b: Effect of school-quality differentials on cross-boundary housing price differentials, alternative tournament performance measures

Dependent variable: Cross-boundary differential in the log of housing price (in 2016 RMB)			
	Subsample: within 150 m to border		
	(1)	(2)	(3)
Diff: Dummy: having at least one first prize	0.023		
	(0.032)		
Diff. Dummy: top decile of math score distribution		0.139**	
		(0.064)	
Diff. Dummy: top decile of Chinese score distribution		-0.005	
		(0.058)	
Diff. Dummy: top decile of English score distribution		-0.071	
		(0.051)	
Diff. Dummy: top decile of comprehensive score distribution		0.116**	
		(0.053)	
Diff. Dummy: top decile of latent score (math and comprehensive)			0.172***
			(0.062)
Diff. Dummy: 75th to 90th percentile of latent score (math and comprehensive)			0.050
			(0.035)
Diff. Dummy: 60th to 75th percentile of latent score (math and comprehensive)			0.039
			(0.024)
Diff. Dummy: former magnet school	0.057*	-0.021	-0.001
	(0.031)	(0.034)	(0.037)
Observations	5,184	5,184	5,184
R-squared	0.028	0.097	0.072

Notes: See Table 4 for notes.

Table 7: Price effect of school boundary adjustment

Dependent variable: Log of the average per-square-meter price of RDP in month *t*	
	(1)
Treated*Dummy: *t* > Apr 2016	-0.130***
	(0.018)
Month fixed effects	Yes
RDP fixed effects	Yes
Observations	220
R-squared	0.924

Notes: *** p<0.01, ** p<0.05, * p<0.1 Heteroskedasticity-robust standard errors are in parentheses.

Appendices: Supplemental tables and figures

Table A1: Details on tournaments

Tournament name	Prize levels			
	1st prize	2nd prize	3rd prize	4th prize
Mathematics				
The Asian-Pacific Cup (Dec 2014 - March 2015)	86	294	442	856
The Central-Ring Cup (Dec 2014 - March 2015)	110	244	480	NA
The Bright-Kid Cup (Dec 2014 - March 2015)	4	60	183	739
The Beautiful-Math Cup (Dec 2014 - March 2015)	96	165	196	NA
Chinese				
The Rainbow Cup (Nov 2014)	35	81	131	31
The Shanghai-Hong Kong Cup (Nov 2011)	44	145	610	NA
English				
The Five-Star Cup (Nov-Dec 2010)	22	42	37	97
The Five-Star Cup (Nov-Dec 2011)	46	123	171	158
The Five-Star Cup (Nov-Dec 2013)	4	21	22	186
Comprehensive (math-Chinese-English combined)				
The Spring-Bud Cup (Dec 2013-Jan 2014)	9	21	40	213
The Spring-Bud Cup (Dec 2014-Jan 2015)	8	26	58	288

Notes: We report the number of students winning each prize for each tournament in Table A1.

The data sources for each tournament are as follows:

The Spring-Bud Cup: http://jzb.com/bbs/thread-2784829-49-1.html.

The Five-Star Cup: http://sh.aoshu.com/e/20111229/4efc283310d0b.shtml.

The Rainbow Cup: http://jzb.com/bbs/thread-3177908-1-1.html.

The Shanghai-Hong Kong Cup: http://jzb.com/bbs/thread-3177908-1-1.html.

The math cups: http://jzb.com/bbs/thread-3269507-1-1.html;

http://sh.aoshu.com/e/20150323/550f849d2bd8c.shtml;

http://sh.aoshu.com/e/20150320/550ba1c6e753e.shtml.

Table A2: Correlations between tournament performance and school input characteristics

Dependent variable: School's tournament performance measure		
	(1)	(2)
Log total enrollment	38.806***	37.699***
	(6.891)	(7.284)
Dummy: former magnet school	39.148***	22.847***
	(6.832)	(6.154)
Student-to-teacher ratio	-0.554	-0.953*
	(0.560)	(0.518)
Percentage of senior teachers	-13.502	-50.493**
	(18.466)	(21.843)
Observations	245	133
pseudo-R-squared	0.083	
R-squared		0.459

Notes: In the regressions, we exclude the five schools that have scores greater than 200.

Table A3: Regression results of the boundary-fixed-effect model, excluding neighborhood controls

Dependent variable: log of price per square meter (in 2016 RMB)					
	All sales	Subsample: within 250 m to border	Subsample: within 200 m to border	Subsample: within 150 m to border	Subsample: within 150 m to border
	(1)	(2)	(3)	(4)	(5)
Dummy: tournament superstar	0.084**	0.073*	0.107**	0.137**	0.164***
	(0.040)	(0.041)	(0.043)	(0.060)	(0.040)
Dummy: upper-middle tournament performance	0.009	0.000	-0.008	-0.015	-0.009
	(0.022)	(0.022)	(0.022)	(0.025)	(0.027)
Dummy: lower-middle tournament performance	-0.025	-0.064***	-0.055***	-0.014	-0.014
	(0.019)	(0.022)	(0.019)	(0.021)	(0.022)
Dummy: former magnet school	0.063*	0.096***	0.087**	0.038	
	(0.034)	(0.036)	(0.038)	(0.044)	
Housing characteristics	Yes	Yes	Yes	Yes	Yes
Neighborhood characteristics	No	No	No	No	No
Boundary fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	10,472	7,796	6,618	5,184	5,184
R-squared	0.687	0.691	0.697	0.648	0.648

Notes: See Table 3 for notes.

Table A4: Hedonic price regressions, housing price versus rental price

	All sales		Within 150m of border	
	Log house price	Log rental price	Log house price	Log rental price
	(1)	(2)	(3)	(4)
Floor-to-area ratio	0.014	-0.019	0.015	-0.001
	(0.011)	(0.026)	(0.013)	(0.034)
Green-space ratio	0.588***	0.224	0.604***	0.086
	(0.095)	(0.223)	(0.132)	(0.310)
Monthly management fee	0.041***	0.086***	0.043***	0.071***
	(0.010)	(0.021)	(0.014)	(0.022)
Building age	0.000	0.004**	0.001	0.001
	(0.001)	(0.002)	(0.001)	(0.002)
Log distance to city center	-0.342***	-0.082	-0.251***	-0.155***
	(0.046)	(0.055)	(0.043)	(0.047)
% households with a college graduate	0.193***	1.241***	0.187**	1.117***
	(0.073)	(0.189)	(0.078)	(0.219)
% households with a local hukou	-0.208**	-1.226***	-0.052	-1.443***
	(0.081)	(0.234)	(0.111)	(0.257)
% households with a child younger than 11	0.197*	0.986***	0.006	0.662***
	(0.110)	(0.270)	(0.118)	(0.209)
% households with a high-income occupation	0.186**	0.149	0.109	0.084
	(0.083)	(0.253)	(0.102)	(0.239)
% housing units self-owned	0.050	1.548***	0.064	1.714***
	(0.052)	(0.213)	(0.065)	(0.202)
Observations	10,472	10,035	5,184	4,984
R-squared	0.578	0.452	0.483	0.458

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$ Standard errors in parentheses are clustered at the school-attendance-zone level. Columns 1 and 3 use the log of the housing price per square meter as the dependent variable. Columns 2 and 4 use log of the neighborhood committee's average monthly rent as the dependent variable. The regressions of columns 1 and 3 additionally include the house-level characteristics, such as the log of internal floor area, dummies for building height (short, middle, tall), floor level, interactions of building-height dummies and floor level, dummies for internal condition (raw, simple, fair, delicate, luxury), and dummies indicating number of bedrooms (one, two or more).

Table A5: School quality of private primary schools

	Private schools (N=90)		
	Mean	S.D.	Obs.
Tournament performance	39.9	91.3	90
Total enrollment	841.29	568.12	82
Student-to-teacher ratio	13.69	6.07	76
Percentage of senior teachers	0.44	0.23	62

Table A6: Correlations between the private-school quality index and neighborhood characteristics

Dependent variable: Private-school quality index of RDP	
	(1)
Floor-to-area ratio	-0.793
	(0.574)
Green-space ratio	12.698**
	(5.610)
Monthly management fee	-0.290
	(0.507)
Building age	0.034
	(0.040)
Log distance to city center	-8.781***
	(0.901)
% households with a college graduate	3.130
	(3.100)
% households with a local *hukou*	12.885***
	(3.533)
% households with a child younger than 11	-24.091***
	(4.195)
% households with a high-income occupation	-1.265
	(4.188)
% housing units self-owned	-2.112
	(3.238)
Observations	1,667
R-squared	0.092

Notes: *** p<0.01, ** p<0.05, * p<0.1 Heteroskedasticity-robust standard errors are in parentheses.

Table A7: Effect of school-quality differentials on cross-boundary housing price differentials, different superstar cutoff percentiles

Dependent variable: Cross-boundary differential in the log of housing price (in 2016 RMB)				
	Subsample: within 150 m to border			
	(1)	(2)	(3)	(4)
Diff. Dummy: tournament superstar (top 5%)	0.167***			
	(0.059)			
Diff. Dummy: upper-middle (75% to 95%)	0.064**			
	(0.027)			
Diff. Dummy: tournament superstar (top 10%)		0.146***		
		(0.035)		
Diff. Dummy: upper-middle (75% to 90%)		0.050		
		(0.030)		
Diff. Dummy: tournament superstar (top 15%)			0.102***	
			(0.037)	
Diff. Dummy: upper-middle (75% to 85%)			0.056**	
			(0.024)	
Diff. Dummy: tournament superstar (top 20%)				0.089***
				(0.030)
Diff. Dummy: upper-middle (75% to 80%)				0.047**
				(0.019)
Diff. Dummy: lower-middle (50%-75%)	-0.000	-0.002	-0.005	-0.004
	(0.022)	(0.022)	(0.022)	(0.022)
Observations	5,184	5,184	5,184	5,184
R-squared	0.051	0.056	0.043	0.041

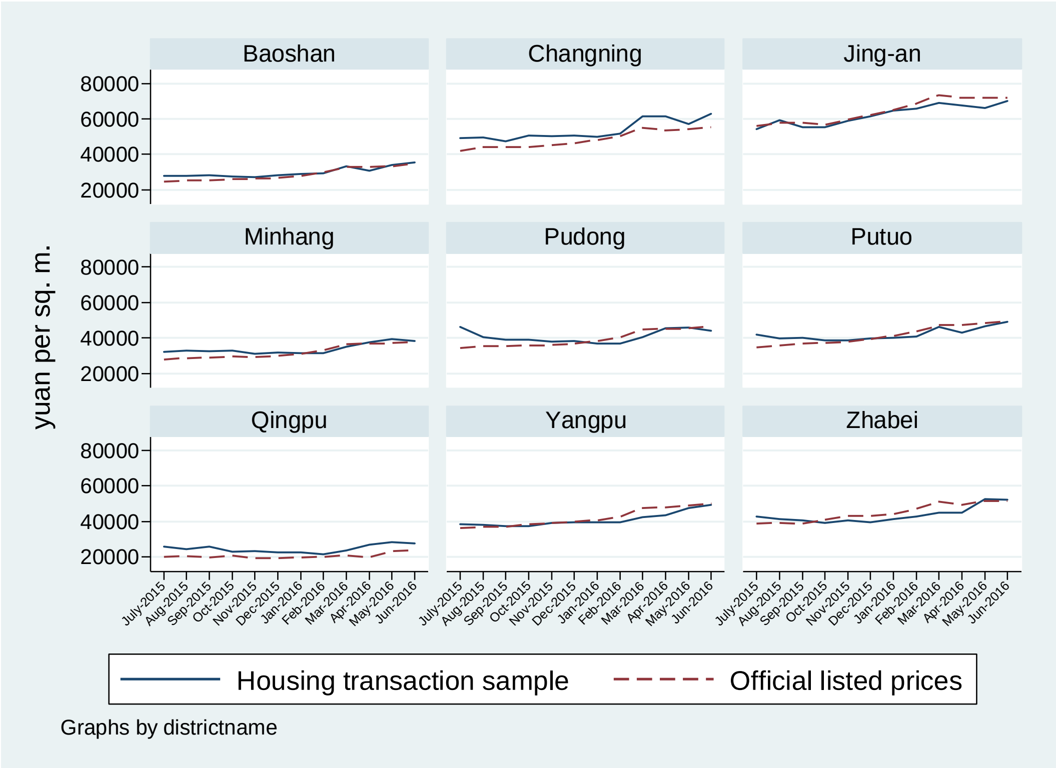
Notes: See Table 4 for notes.

Table A8: Effect of school-quality differentials on cross-boundary housing price differentials, matching with a maximum pairwise distance

Dependent variable: Cross-boundary differential in the log of house price (in 2016 RMB)					
	All sales	Subsample: within 250 m to border	Subsample: within 200 m to border	Subsample: within 150 m to border	Subsample: within 150 m to border
	(1)	(2)	(3)	(4)	(5)
Diff. Dummy: a tournament superstar	0.116**	0.130**	0.148***	0.139***	0.143***
	(0.051)	(0.051)	(0.055)	(0.052)	(0.036)
Diff. Dummy: the upper-middle tournament performance	0.030	0.034	0.037	0.046	0.048
	(0.022)	(0.025)	(0.026)	(0.028)	(0.031)
Diff. Dummy: the lower-middle tournament performance	-0.005	-0.005	-0.003	-0.003	-0.003
	(0.020)	(0.022)	(0.020)	(0.022)	(0.022)
Diff. Dummy: a former magnet school	0.031	0.026	0.015	0.006	
	(0.035)	(0.036)	(0.039)	(0.040)	
Observations	9,533	7,540	6,438	5,068	5,068
R-squared	0.055	0.062	0.065	0.056	0.056

Notes: See Table 4 for notes. For the construction of the control sale, we use only properties on the opposite side of the boundary that are located inside a 1-km ring around the actual sale.

Figure A1: Representativeness of housing transaction sample



Notes: The official listed prices are the listed prices of all apartments on the market in Shanghai from July 2015 through June 2016. The data are obtained from the *China Real Estate Association*.