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School allocation rules and housing prices: A quasi-experiment with school relocation events in Singapore☆

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ABSTRACT

This study uses a unique distance-based school allocation priority rule in Singapore as an identification to test school relocation effects on housing prices in the school zone. Using housing samples during the period from 1999 to 2009, our main results show that private housing prices within 1-km zone and in 1-km to 2-km zone from the old school zone decline by 2.9% and 6.0%, respectively, 6 months before the school relocation events. Larger price declines of 5.5% and 6.9% are found for houses located in 1 km and 1 km to 2 km school zones 12 months before the school relocations. In the public housing market, we find that school relocations cause significant housing price declines of between 0.7% and 1.4% for households living within the 1-km school zone. The school relocation treatment effects are amplified by the school popularity ranking. The prioritization in school allocation accorded to houses within 1-km school zone has significant economic value in the private housing market.

1. Introduction

Government schools and government-aided schools[1] collectively form the public school system in Singapore. The Ministry of Education (MOE) envisions an objective of *every school is a good school*, where every school is given resource to develop areas of excellence and every child is given an equal opportunity to develop holistically in every school. Despite the government's concerted effort in leveling the playing field for every school, parents will not stop finding ways to get their children into popular schools; the competition for admission in these schools is intense. The Singapore's Prime Minister Lee Hsien Loong acknowledged the deeply rooted rent seeking behavior of parents in his National Day Rally speech on August 18, 2013:

> *within the same housing estate, two separate schools, few hundred meters apart, parents will go to great lengths to bring their children into School A (popular school) instead of School B. … Having got a place in a good school, they want a place in another school, which in their view will be better for their kid. Sometimes they succeed, sometimes they do not. But the belief is very deep.*

He alludes to the story of Mencius's mother[2] when describing a mother who moved four times within Singapore just to increase the chance of getting her oldest child into a good primary school. In Singapore, except for children whose parents have special affiliations,[3] Singapore citizen (SC) or Singapore Permanent Resident (SPR) children are given priority admission only if they live close to schools. Like the school attendance districts in the US, families of both SCs and SPRs living within 1-km followed by a 1- to 2-km radius from a school will

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[1] There are 175 primary schools consisting of 134 government schools and 41 government-aided schools as of 2012. Government schools usually have religious and/or clan affiliations. These schools are heavily funded by the government and are required to follow the syllabus and curriculum stipulated by the Ministry of Education (MOE) of Singapore, but they have some degree of autonomy in their operation.

[2] Mencius, also known as Meng Ke or Ko, was a famous Chinese philosopher and a principal interpreter of Confucianism.

[3] The affiliated parents include those, who were former students of schools; who are members in the School's management and advisory board; who work as teaching staff in schools. See Section 2 for more details.

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have the priority in school allocation. The home–school distance-based allocation rule has created many modern "Mencius's mothers" among Singaporeans. Housing mobility is significantly driven by wanting to live close to good schools.

We exploit the distance-based school allocation rules in Singapore in our identification strategies by sorting houses into the "treatment" groups if located within the two priority zones: within 1-km ("TREAT1") and 1- to 2-km ("TREAT2"), and other houses in the 2- to 4-km boundary into the "control" group. The 4-km cut-off boundary is used in the same spirit as Black's (1999) to reduce boundary discontinuity effects between the treatment and the control samples. If school distance rule is significantly capitalized by families into housing prices, we should expect houses located within the 2-km boundary (Treat1 and Treat2) to command positive premiums vis-à-vis the control housing samples located in the 2- to 4-km zone. If "good" schools as mentioned in the Prime Minister's speech matter, we should expect parents to be willing to pay higher premiums for houses located in the 2-km boundary to "good" schools relative to average schools. For SC and SPR families without school going age children and for foreigners who are not eligible for the distance-based allocation exercises,[4] proximity to schools may bring more negative externalities, such as noise and congestion, than possible economic benefits, if they choose to live in houses near to schools. However, the negative externalities may not affect investors, who buy houses in school zones for rental income and capital gains purposes.

Decisions to relocate schools by the social planners will have positive impact on social welfare distributions. Some residents are happy when a new school is built in the neighborhood, while others are disappointed when an existing school is moved away from the neighborhood. The school relocations are random events to parents, who should not have a-priori access to the information. In this study, we use 16 school relocation events in Singapore as a natural experiment to test significance of capitalization (discount) of the school distance rule into housing prices in new (old) school zones. In our experiment, we exploit the school relocation events as the exogenous shocks in a difference in differences (Diff-in-Diff) framework to test for variations in school distance capitalizations (discounts) between the treatment samples (houses located within the 1-km and 1-km to 2-km school zones) and the control samples (those located outside the 2-km school zone) in both the new and old school locations. The modern "Mencius's mother" story could not be rejected, if we observe a significantly positive capitalization effect in neighborhoods that gain a new school, and/or a significantly negative capitalization effect in neighborhoods that lose a school.

This study uses school relocation events and the unique 2 km home–school distance-based priority allocation rule to test the school capitalization effects in Singapore for the periods from 1999 to 2009. Our main results show that school relocation events cause significant price declines of 2.9% and 6.0% for private houses located within 1-km zone and in 1-km to 2-km zone from the old school zone, when the school relocation news were revealed 6 months before the relocation. Larger price declines of 5.5% and 6.9% associated with the loss of a school are found for houses located the 1 km and 1 km to 2 km from the school locations, when the school relocation events were revealed 12 months earlier. In the public housing market, we also find that school relocations cause significant welfare losses of between 0.7% and 1.4% for households living within the 1-km school zone.

The treatment effects of the school relocation events were amplified in the areas that are affected by relocations of schools in the top 50 popularity ranking. In the private housing market, the loss of a top 50 ranking school causes housing prices to decline by 8.5% and 12.2% for the 1-km and 1-km to 2-km old school zones, respectively. The comparable declines in public housing prices are estimated at 5.1% and 2.4% for the 1-km and 1-km to 2-km old school zone, respectively. We also empirically tests economic values associated with prioritization in the school allocation zone, which is bounded by 2 km distance to the old school location. We found that the prioritization rule as identified by the 1-km school zone to be more relevant in the private housing market than in the public housing market. We also find other distance-related effects to affect housing prices in the 1-km school zones. In the public housing estate, negative externalities associated with school noise and congestion could not be ruled out for houses located within 200 m from the schools. However, houses located within accessibility range (201 m to 200 m in the public housing market, and 301 m to 400 m in the private housing market) are also found to command positive premiums. We empirically test the school relocation events in the new school zone using the overlapping school zone, where the school allocation priority is unaffected by the school relocations, as the treatment, and find that the housing relocation events create positive treatment effects that cause price gap between the overlapping and the new school zones to disappear after 6 months of the relocation events in both the private and public housing markets.

This study contributes makes several new findings to the current literature on school capitalization effects in housing prices. First, we use the home–school distance as our identification and the school relocation events as our exogenous shocks to test for the school capitalization effects. Differences in housing prices within and outside the school priority allocation zones at the old school locations are clean verifications of the school effects in our study. Like the school redistricting policies in the US, school relocations in Singapore are also a randomized exercise that gives us a natural experiment to address potential endogeneity problems between housing prices and school distance. Second, we use sample houses in the 2 km school zone to verify that the prioritization advantage in the school allocation rule could have positive economic values, especially for houses in the private housing markets. Third, we test if welfare losses in the old school locations will be translated into welfare gains in the new school locations. We find that the housing prices in the new school zone increase significantly after the relocation, and the price gaps with the overlapping zone, which enjoys the school prioritization privilege prior to relocation, disappear following the equalization of the school allocation prioritization advantages after the school relocation events.

The remainder of the paper is organized as follows. Section 2 reviews past literature on capitalization effects of school attendance zones on housing prices and the impact of school choice and school segregation policies. Section 3 presents some institutional details on the education system, particularly the primary school allocation policies, in Singapore. Section 4 discusses data sources and descriptive statistics. Section 5 lays out the empirical strategies, and Section 6 discusses empirical results of the tests. Section 7 concludes the study.

2. Literature review

There is a long list of literature that has shown significant capitalization of school performance into housing prices.[5] Most of the studies were found in the United States (US), which used school test scores and housing prices data from different states, such as Illinois (Downes and Zabel, 2002; Bonilla et al., 2015), Connecticut (Clapp and Ross, 2004; Clapp et al., 2008; Dhar and Ross, 2012), Florida (Figlio and Lucas, 2004), Louisiana (Zahirovic-Herbert and Turnbull, 2008), Massachusetts (Hilber and Mayer, 2009; Black, 1999), Minnesota (Reback, 2005), and North Carolina (Bifulco et al., 2009). Positive effects of school performance on housing prices were also found in other developed countries such as Canada (Bogart and

[4] Please read Section 3 of this paper on the detailed discussion on the primary 1 school allocation exercise in Singapore.

[5] See Gibbon and Machin (2008), Black and Machin (2010), Nguyen-Hoang and Yinger (2011), and Machin (2011) for comprehensive reviews of recent studies on capitalization of school quality in housing prices.

Cromwell, 2000; Ries and Somerville, 2010), the United Kingdom (Gibbon and Machin, 2003, 2006, 2008; Gibbons et al., 2013), and France (Fack and Grenet, 2010). In Beijing, China, Zheng et al. (2014) found a 7.2% premium for houses located within the attendance zone of key primary schools.

Are high performing schools usually located in high-income neighborhoods? Few studies have attempted to disentangle the effects of school quality from unobserved neighborhood attributes. Black (1999) argues that boundary discontinuities, if existent, across either side of a school attendance zone, give a clear identification of school quality effects on housing prices if neighborhood attributes are held constant. The boundary discontinuity design subsequently improved by Bayer et al. (2007); Fack and Grenet (2010); and Gibbons et al. (2013) has since become a popular approach to estimate price variations across two closely-spaced school attendance districts. Dhar and Ross (2012) further extend the study to larger school district boundaries due to technical difficulty in measuring the school attendance zones in some states.

The difference-in-differences ("Diff-in-Diff") approach is another popular approach used by researchers to separate school and neighborhood effects. Bogart and Cromwell (2000) use school redistricting events to test the causality of school quality on housing prices in Shaker Heights, Ohio. They found that school redistricting causes disruptions to neighborhood and racial composition in public schools, which reduces house value by 9.9%, ceteris paribus. First, the neighborhood school effect implies that parent involvement and student participation in school activities reduces after redistricting, causing school quality to deteriorate. Second, redistricting reduces the willingness of racially prejudiced parents to pay for neighborhoods with less desegregated schools. Ries and Somerville (2010), using school boundary changes as a natural experiment in the "Diff-in-Diff" framework, found significant capitalization of school quality into housing prices, especially in the high income neighborhoods in Vancouver, Canada. The positive capitalization of school quality on housing prices also holds when school district boundary changes in Connecticut, US were used as the treatment in the tests by Dhar and Ross (2012). Like school redistricting policy, inter-district school choice programs are found to have the same diminishing capitalizing effects on housing prices in school districts that accept transfer students (Reback, 2005; Brunner et al., 2012). The opposite (positive) capitalization effects are found in school districts that allow students to transfer to preferred school districts. Bonilla et al. (2015) find that changes in school admission policies in Chicago that increase chance of students living in close proximity to magnet schools increase housing prices in the areas that are within 1.5 mile from the magnet schools.

Bayer et al. (2007) found that Tiebout sorting of educated and high-income families onto the side of a neighborhood with better schools results in significant capitalization of school quality into housing prices. If school scores are endogenously affected by peer effects (Machin, 2011), increasing spending on improving teaching quality of schools will have no impact on housing prices as predicted by Downes and Zabel (2002). However, this hypothesis was rejected in a more recent study by Cellini et al. (2010), who found that housing price variations are significantly explained by capital expenditure per student but are not significantly related to test scores. The positive school expenditure and housing price capitalization effects supported by the studies of Brunner and Sonstelie (2003) and Hilber and Mayer (2009), which show that homeowners and elderly residents without school-going children vote for high local school spending.

Do rich parents place a higher value on better school scores relative to poor parents in a given neighborhood? If children from rich families could attain better scores by accessing value-added enrichments, parents capitalize high average scores (output) over school resources (input) on housing prices (Brasington and Haurin, 2006; Kane et al., 2006). These parents are more likely to draw additional information from state-assigned school ratings to identify school achievement, and Figlio and Lucas (2004) showed that schools with higher ratings have a higher capitalization effect on housing prices. Gibbon and Machin (2006) suggested that popularity of over-capacity schools is also a positive signal that commands an additional premium relative to under-capacity schools with equal performance.

Clapp et al. (2008) found that parents value school ethnic composition more than school test scores as a signal of school quality. Changes in pupil ethnicity in Connecticut schools are found to have incremental capitalization effects on housing prices. Clapp and Ross (2004) argue that changes in school segregation are influenced by demographic trends and labor market factors in urban areas. Bifulco et al. (2009) showed that school choice programs contributed to the school segregation using Durham's schools as an experiment. They also showed that school choice programs cause more segregation by class than by race of pupils. Baum-Snow and Byron (2011), however, showed that the school segregation policy has also wider impact on the resorting of households and the enrolments of private schools in urban areas in the US. The results support Tiebout's *vote on your feet* hypothesis that school desegregation causes whites to move to the suburbs of many US cities.

3. Primary school admission system in Singapore

Primary school admission is highly competitive in Singapore. Many parents will go the extra "kilometer" to get their children into popular schools, despite the repeated assurance by the Singapore's Ministry of Education (MOE) that it will strive to achieve the goals of making *every school a good school*. The government acknowledges the differences in the perspective of the government and that of the parents; as Singapore's Prime Minister Lee Hsien Loong put it during his National Day Rally Speech on August 18, 2013[6]:

> There are two different perspectives on education, on schools in Singapore. One is the MOE perspective — *every school is a good school*. … we give every school the teachers, the resources, the backing. We help many of our schools develop niches of excellence. We make sure that the whole system is of a high standard. But parents and students have a different perspective. They accept the MOE argument but they still have strong preferences for certain schools.

There were 175 primary schools in Singapore consisting of 134 government schools and 41 government aided schools[7] as of 2012. The schools admitted 39,582 primary one students in 2012, and these school enrolment numbers are closely correlated with childbirth six years prior (Fig. 1).[8] Primary one registration usually starts in July or August every year. Children who are six-years-old on 1 January in the admission year are eligible to register for primary one admission for the following year. The MOE adopts an allocation system consisting of seven phases, which are divided into *Phase 1*, *Phase 2 A*(*1*), *Phase 2 A*(*2*), *Phase 2B*, *Phase 2C*, *Phase 2C*(*Supplementary*), and *Phase 3* (Table 1). Allocation of placements in primary one in each school is made sequentially from Phase 1 to Phase 3 in a descending order. Children who are Singaporean citizens and Singapore Permanent Residents (SPRs) can participate in any of the Phases. However, children who are neither Singaporeans nor Permanent Residents can only participate in Phase 3.

Phase 1, Phase 2 A(1) and Phase 2 A(2) assign priority to students affiliated with schools, which include children with siblings currently studying in the schools, whose parents and siblings are alumni of the schools, whose parents are members of advisory and management boards of schools, or whose parents are teaching staff in schools. Schools

[6] Source: Office of the Prime Minister, Singapore. http://www.pmo.gov.sg/content/pmosite/mediacentre/speechesninterviews/primeminister/2013/August/prime-minister-lee-hsien-loong-s-national-day-rally-2013-speech.html.

[7] Government-aided schools usually have religious and/or clan affiliations. These schools receive grant-in-aid from Singapore's government to fund recurrent expenditures. The funds are supplemented by other private sources such as fund-raising activities. They are required to follow the syllabus and curriculum stipulated by the Ministry of Education (MOE) of Singapore, but they have some degree of autonomy in their operation.

[8] Source: *Education Statistics Digest* 2013, Ministry of Education, Singapore.

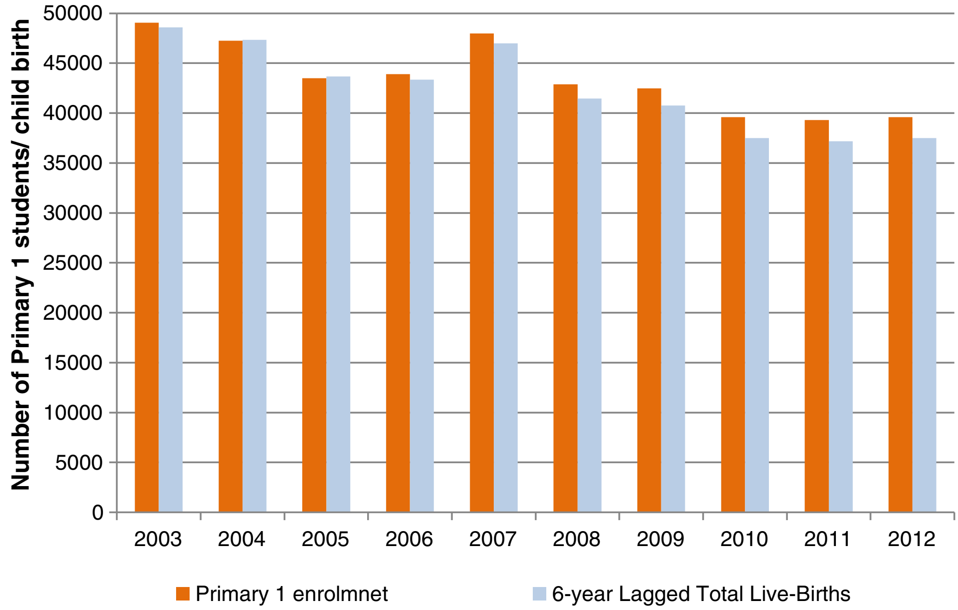


Fig. 1. Primary 1 school enrolment and 6-year lagged live-births: 2003–2012. Note: The figure plots the trends in primary 1 enrolment and child birth rate lagged by 6 years. In Singapore, children enroll into primary 1 at the age of 7, and the child-birth rate 6 years ago could be a leading indicator of the primary 1 enrolment.
Source: Ministry of Education, Singapore.

will usually set aside enough places to ensure that eligible children in these phases will be allocated an admission to the schools. After Phase 2 A(2), the remaining places in each school are divided equally for Phase 2B and Phase 2C. Phase 2B is reserved for students, whose parent has either given at least 40 h of voluntary service to the school, is a member endorsed by the church or clan directly connected with the primary school, or is endorsed as an active community leader. Phase 2C is open to other eligible Singaporean and SPR children, who do fall into any of the categories in Phase 1 through Phase 2B.

Home–school distance prioritization is used in these two phases (2B and 2C) to assign primary admission places to children living in close vicinity to school, ceteris paribus. The distance-based rules assign places sequentially to children living within 1-km radius of the school, followed by children living between 1 and 2 km from the school. If there are more children living between the 1- and 2-km boundary than there are available places and balloting is conducted to assign places in these two phases, children living outside 2-km radius of the school will be accorded the lowest priority. They will not be admitted to the school, if demand by families living within 2-km radius from the school exceeds the total available places.

4. Data sources and empirical design

4.1. School distance measurements

According to the MOE statistics,[9] there were 18 school relocation events from December 1999 to January 2009; two of the events were dropped from our samples because of the dearth of transaction data. Table 2 summarizes the details of the relocations, including the date of the move, the old and new school locations (postal codes), and the relocation distance. We also included the popular ranking dummy "DUMTOP50", which measures the popularity of schools based on two indicators. The first indicator is the academic ranking of the schools by an independent source,[10] and the second indicator is the oversubscription rate of the Phase 2C intake[11] for the period 2006–2008. The dummy has a value of 1 if a school is ranked in the top 50 based on the two indicators. The descriptive statistics (Table 3) show that more top 50 popular schools (49.6%) are located in the private housing areas than in the public housing areas (21.8%).

The MOE relocates schools for several reasons: school expansion, increase in student numbers, urban development, lack of facilities, congestion, noise to the vicinity, unsafe building structure, or government's allocation of new school site (Ho, 2004). During the pre-independence periods prior to 1965, the lack of space for expansion has been the main reasons for the early relocation of schools. Changing demographic (declining school going children cohorts) and urban planning have been the main reasons affecting the school relocation in the post-independence periods. In 1999, the 10-year program for rebuilding and improving existing schools (PRIME) was established to improve the information technology and infrastructure of schools, which also resulted in some schools being relocated to new locations. More schools are also expanded in the 2000s to accommodate various school programs, which include single session schools, mixed gender schools, mixed age schools (co-locating junior and high schools in a single premise). The school relocation events are, however, exogenous; and the MOE's decisions to relocate schools are not privy to the public.

We used the dummy variable "NEW" to denote a new school location and "OLD" to denote an old school location. Fig. 2 gives the spatial distributions of the 16 schools in the 32 neighborhoods ("NEW" and "OLD") in our samples. The affected schools are randomly distributed across the central, outer central, north-eastern, and northern parts of the island, and the relocation distances vary by school.

4.2. Housing data

Singapore has a two-tiered housing market comprising a public housing market and a private housing market. In the public housing market, the government, via its public housing agency — Housing and

[9] The data was obtained from the MOE and respective school websites.

[10] The academic ranking exercise was compiled by a private school consulting network ("KiasuParents.com"), and the scores are accessible at http://www.kiasuparents.com/kiasu/content/singapore-primary-schools-ranked-academic-excellence.

[11] The statistics were published by the MOE. Phase 2C was chosen because it is the open category (no priority allocation is given), and the number of excess applications for placement serves as a good indicator of the school's popularity.

Table 1
Rules on primary 1 school allocation system in Singapore.
Source: Ministry of Education, Singapore.

Eligibility	Primary one registration phase	Applicability of distance-based priority
For children who are Singapore citizens or Singapore Permanent Residents	*Phase 1* For a child who has a sibling studying in the primary school of choice	No
	Phase 2 A(1) (a) For a child whose parent is a former student of the primary school and who has joined the alumni association as a member not later than 30 June (in the previous year). (b) For a child whose parent is a member of the School Advisory/Management Committee	No
	Phase 2 A(2) (a) For a child whose parent or sibling has studied in the primary school of choice (b) For a child whose parent is a staff member of the primary school of choice	No
	Phase 2B (a) For a child whose parent has joined the primary school as a parent volunteer not later than 1 July 2012 and has given at least 40 h of voluntary service to the school by 30 June (in the current year). (b) For a child whose parent is a member endorsed by the church/clan directly connected with the primary school (c) For a child whose parent is endorsed as an active community leader	Yes
	Phase 2C For all children who are eligible for primary one in the following year and are not yet registered in a primary school	Yes
	Phase 2C Supplementary For a child who is not yet registered in a school after Phase 2C	Yes
For children who are not Singapore citizens or Singapore Permanent Residents	*Phase 3* For a child who is neither a Singapore citizen nor a Singapore Permanent Resident	No

Note: The table summarizes various phases of the primary 1 allocation process in Singapore, and the right hand column indicates whether the home–school distance rule is applicable in each phase.

Table 2
School relocation events from 1999 to 2009.

No	Date	Current school name	Region	New school postal code	Old school postal code	Distance between old and new school locations (km)	Top 50 by popularity (1 = yes, 0 = no)
1	Dec-1999	Haig Girls' Sch	Geylang	427072	437128	1.094	0
2	Dec-2000	Temasek Pr	Bedok	469300	469268	2.197	1
3	Dec-2001	CHIJ Our Lady of the Nativity	Hougang	534793	828869	3.207	0
4	Jan-2001	Teck Whye Pr	Choa Chu Kang	688261	688943	0.684	0
5	Jan-2002	Si Ling Pr	Woodlands	739067	739146	1.705	0
6	Mar-2004	River Valley Pr	Central	237993	238372	0.450	0
7	Jan-2009	Anglo-Chinese Sch (Junior)	Central	227988	309919	1.389	1
8	Jan-2006	Fuchun Pr	Woodlands	739063	738926	0.809	0
9	Jan-2002	Bukit Timah Pr	Bukit Timah	598112	598668	0.940	0
10	Jan-2000	Blangah Rise Pr	Bukit Merah	109100	098888	1.307	0
11	Jan-2000	Poi Ching Pr	Tampines	529067	319320	9.176	0
12	Jan-2000	Raffles Girls' Pr	Bukit Timah	289072	278790	2.746	1
13	Jan-2001	Nan Chiau Pr	Sengkang	545080	239351	12.498	1
14	Jan-2004	Woodlands Pr	Woodlands	738853	739063	1.729	0
15	Jan-2005	Mee toh pr	Punggol	828867	218644	10.472	0
16	Jan-2000	May flower primary	Ang Mo Kio	569,878	569920	0.930	0

Note: The table summarizes the details of schools, including their old and new postal codes, regions, date of relocation, distance between the old and new school (measured in kilometer, km), and also the ranking of the school based on the popularity scores published by kiasuparent.com, a private consulting website. Two schools that are Yio Chu Kang Primary (Hougang) and Hong Wen Primary School (Kallang) are dropped from our samples due to lack of matched housing samples during the relocation event windows.

Development Board (HDB), builds and sells housing flats at subsidized prices to eligible Singaporean buyers, who meet income and other criteria.[12] There exists a secondary market, which is commonly known as a resale HDB market, where public housing owners could sell their flats after meeting the 5-year minimum occupation period requirement.[13] Like the private housing market, which operates as a *laissez-faire* market, prices of resale HDB flats are determined by market forces. While foreigners are free to buy private condominium and apartments in Singapore[14]; public housing flats could only be sold to Singapore citizens and permanent residents.

We collected the non-landed private housing and the public resale housing transactions data for the period 1998–2011. The private housing transaction data were obtained from the Real Estate Information System of Singapore (REALIS) database of the Urban Redevelopment

[12] The government sets an income ceiling of S$12,000 per month for households to be eligible to buy subsidized public housing flats. This policy is to ensure that housing is affordable for low and medium families.

[13] At the block and precinct level, the ethnic integration policy is imposed to set quotas on Chinese and non-Chinese households to avoid high concentration of selected ethnic groups in public housing block/precinct.

[14] Under the Residential Property Act in Singapore, there is no restriction on foreigners to purchase condominiums, but they are only allowed to purchase apartment units that are 6-storey and above. Condominiums and apartments are both non-landed housing, but they are differentiated by the size of lands on which they are built. Condominium developments are built on lands that are at least 0.4 ha, and come with full recreational facilities and amenities; whereas apartment developments are not bound by the minimum land plot constraint.

Table 3
Descriptive statistics.

Variables	Symbol	Full Sample	Private Housing	Public Housing	Old School Location		New School Location	
					Treatment within 2 km	Control 2 km < X ≤ 4 km	Treatment within 2 km	Control 2 km < X ≤ 4 km
Observation		135,788	46,655	89,133	45,258	64,490	45,772	60,767
Log-housing price	LNPRICE	12.770	13.559	12.356	12.810	12.764	12.796	12.779
		(0.703)	(0.430)	(0.398)	(0.793)	(0.697)	(0.705)	(0.697)
Unit size (m^2)	AREA	107.394	128.286	96.459	109.572	104.669	112.782	106.786
		(45.263)	(63.046)	(26.317)	(46.007)	(49.557)	(41.683)	(49.506)
Condominium	DUMCONDO	0.251	0.731	n.a.	0.278	0.271	0.224	0.277
		(0.434)	(0.444)		(0.448)	(0.444)	(0.417)	(0.448)
Freehold tenure	FREETEN	0.176	0.512	n.a.	0.191	0.200	0.151	0.179
		(0.381)	(0.500)		(0.393)	(0.400)	(0.358)	(0.384)
Resale	DUMRES	0.120	0.349	n.a.	0.163	0.118	0.120	0.116
		(0.325)	(0.477)		(0.369)	(0.322)	(0.325)	(0.320)
New sale	DUMNEW	0.880	0.651	n.a.	0.837	0.882	0.880	0.884
		(0.325)	(0.477)		(0.369)	(0.322)	(0.325)	(0.320)
Buyer type	HDBBUYER	0.166	0.484	n.a.	0.162	0.183	0.142	0.178
		(0.372)	(0.500)		(0.368)	(0.387)	(0.350)	(0.382)
Building age	AGE	18.556	4.897	23.070	19.420	18.668	16.354	18.308
		(11.635)	(7.018)	(9.045)	(11.959)	(12.394)	(10.061)	(11.725)
HDB room type	HDBROOM	2.025	n.a.	2.025	1.944	1.940	2.235	2.001
		(0.894)		(0.894)	(0.896)	(0.881)	(0.839)	(0.915)
Top 50 popular schools	DUMTOP50	0.314	0.496	0.218	0.259	0.331	0.250	0.361
		(0.464)	(0.500)	(0.413)	(0.438)	(0.471)	(0.433)	(0.480)
Distance to old school location (meter)	DISTSOLD	3586.740	3097.532	3842.807	1269.906	2982.398	n.a.	n.a.
		(3113.763)	(2670.179)	(3293.588)	(490.925)	(592.721)		
Distance to new school location (meter)	DISTSNEW	3254.953	3423.993	3166.472	n.a.	n.a.	1180.580	2989.638
		(2501.189)	(2589.634)	(2448.990)			(498.199)	(577.957)

Note: The table summarizes the mean and standard deviation (in parentheses) statistics for the variables used in the empirical studies. The statistics for the full sample, the private and public market subsamples are included. The full samples are further sorted into old and new school, and treatment and control zones. The treatment zone include housing samples that are located within 2 km from school locations, and the control zone include housing samples located between 2 km and 4 km zone.

Authority (URA). The REALIS database contains private residential transaction records from caveats lodged at the Singapore Land Registry.[15] The public housing resale transaction data were obtained from the Housing and Development Board (HDB) database. While the HDB does not regulate resale prices, buyers and sellers are required to submit applications with an agreed resale price to the HDB for approval. In Singapore, transfers of legal rights on properties are effected using dutiable sale and purchase documents, and stamp duty is payable by buyers based on transaction prices reported in the dutiable documents. We expect prices reported in caveats for private properties and also in documents submitted to the HDB to be representative of the actual transaction prices.[16]

We use the dummy variable "PUBLIC", which has a value of 1 for public (HDB) resale transactions and a value of 0 for private non-landed transactions. While public housing sales ("PUBLIC" = 1) include only flats sold in the resale (secondary) markets, private housing sales ("PUBLIC" = 0) include the sales of pre-completed housing units by developers ("NEWSALE" = 1), subsales of pre-completed units by individual buyers ("SUBSALE" = 1), and sales of completed units in the resale markets by individual sellers ("RESALE" = 1). Subsales by individual buyers are considered speculative because the buyers purchased the units with no intention of moving into them and sold the units before gaining physical possession of them.

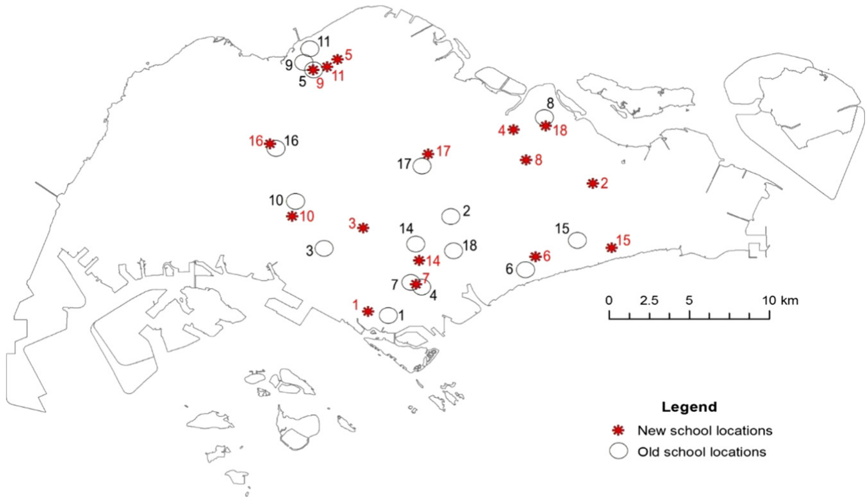
The data contains details on housing attributes, such as the floor area measured in square meters ("SIZE") and the age of the building in years ("AGE"). By referencing to the postal codes of the old location ("OLD" = 1) and the new location ("NEW" = 1) of the sample schools, we measure the continuous linear distance from each housing sample i (identified by its six-digit postal code) to the nearest sample school on an ArcGIS layer (denoted as "DISTANCE"). We drew two circles around each school location using the ArcGIS buffer function, so that the smaller circle of 2-km radius demarcates the home–school priority allocation zone (the treatment zone), and the outer circle of 4-km radius defines the discontinuity boundary. The control zone is the bounded area in between the inner (2-km radius) and outer (4-km radius) rings. In the treatment zone, we further divide the housing samples into two treatment zones to reflect the prioritization in school placement allocation, using ["TREAT1" = 1, if ("DISTANCE" ≤ 1.0 km)] if a housing unit is located within the 1-km radius from the school and ["TREAT2" = 1, if (1.0 km < "Distance" ≤ 2.0 km)] if a housing unit is located between the 1-km and 2-km radiuses from the school. We assign houses located outside the 2-km boundary to the control zone: ["CONTROL" = 1, if (2.0 km < "Distance" ≤ 4.0 km)].

Fig. 3 illustrates how the home–school distances are measured for all samples, and also in special cases, where houses are located in the overlapping zone of two schools (as indicated by the shaded areas). The "X–X" line cutting across the overlapping zone splits the houses into two different groups. The shortest distance approach is used for special cases, when a house is located within 2-km boundary of two independent schools (an overlapping school priority zone).[17] For example, the home–school distance of house "a", which falls within the 2-km school zones of both schools "A" and "B", is measured with reference to school "A" based on the shortest distance criterion. The

[15] In Singapore, lodging caveats is though voluntarily, majority of buyers will still register caveats with Singapore Land Authority (SLA), via their lawyers, to protect their legal interests on transacted properties after exercising options to purchase or signing sales and purchase agreements. The caveat data in REALIS form the main samples used to construct the URA private residential price indices in Singapore.

[16] In Singapore, any willful intent to manipulate sale prices is deemed to be committing a tax evasion offence; and offenders would face serious punishment. We do not expect buyers and sellers to manipulate transaction prices in dutiable documents, as captured in caveat documents submitted to SLA, and also in documents submitted to the HDB for transactions in private and public housing markets, respectively.

[17] The shortest-distance approach assumes that parents prefer a school that is located nearer to their home than another school that is located further away, *ceteris paribus*. However, one may argue that parents, who live within 2-km of two schools, may use the school quality as an additional factor in their school selection decisions. Given only three schools that have overlapping boundary (three schools in Woodlands area) in our samples, we would not able to empirically separate the school distance factor and the school quality factor in the parents' choice for housing in our tests.



No	School name
1	Haig Girls' Sch
2	Temasek Pr
3	CHIJ Our Lady of the Nativity
4	Teck Whye Pr
5	Si Ling Pr
6	River Valley Pr
7	Anglo-Chinese Sch (Junior)
8	Fuchun Pr
9	Bukit Timah Pr
10	Blangah Rise Pr
11	Poi Ching Pr
12	Raffles Girls' Pr
13	Nan Chiau Pr
14	Woodlands Pr
15	Mee toh pr
16	May flower primary

Fig. 2. Distribution of relocated schools for the periods 1999–2009. Note: The map shows distributions of new (circle) and old (star polygon) locations of sample schools used in our empirical analyses. The table above lists the schools with the "numbers" identifying the school locations in the map. Two schools that are Yio Chu Kang Primary School and Hong Wen Primary School are dropped from the study due to lack of matched housing transaction data.

distances of houses "b" and "c" are measured with reference to school "B". The distance of house "b" to school "A" is not captured in the ArcGIS school layer even though the house is located within the 2-km radius from the school. This shortest distance approach truncates the control and the treatment housing samples along the "X–X" line, which means that, for the school "B" zone, houses (including house "b") bounded by the inner 2-km radius ring to the right of "X–X" were identified as the treatment samples, and houses located in between the 2-km and 4-km radiuses (such as house "c") to the right of "X–X" were used as the control samples.

In another scenario, where a school moves to a new location that is less than 2 km from the outer boundary of the old location, an overlapping zone is also identified, where the priority allocation privilege of families residing in this zone is unaffected by school relocation events. If the school "B" in Fig. 3 is represented by the "new" school "A" location, the shaded area represents the overlapping zone ("OVERLAP"), where houses in this zone are within 2 km from both the old and new schools. There are 11 sample school relocation events where an overlapping zone is found between the old and the new school locations; and we denote this zone by "OVERLAP", which has a value of 1 if a house *i* is located in the shaded area and a value of 0 otherwise. We use houses in the overlapping zones as the "control" samples in our experiment to represent family behaviors that are not related to the school distance effects.

4.3. Identification of school relocation events

There were 16 school relocation events in the sample period 1999–2009 (Table 2). The window period in our experiment is defined by an event quarter during which a school relocation event is reported, "τ_0", and the eight-quarter (two-year) periods before and after the event quarter. Sample transactions falling outside the window period were dropped to keep our tests of school relocation events within a tight window. We then defined a binary time dummy variable, "AFTER", which has a value of 1 if a transaction occurs after the event day [$t \geq$ "τ_0"], and a value of 0 for other periods, to separate the treatment window from the pre-school relocation control window. We also tested whether home buyers had prior knowledge of the school relocations by using a pre-event treatment window ["AFTER(t)" $= 1$, if $t \geq$ "$\tau_0 - n$"; and 0 otherwise]. We set two different cut-offs for the treatment time, two quarters (six months) and four quarters (12 months) before the school relocation event time [$t = (\tau_0 - 6)$ and $(\tau_0 - 12)$], and denoted them as "AFTER(-6)" and "AFTER(-12)", respectively.

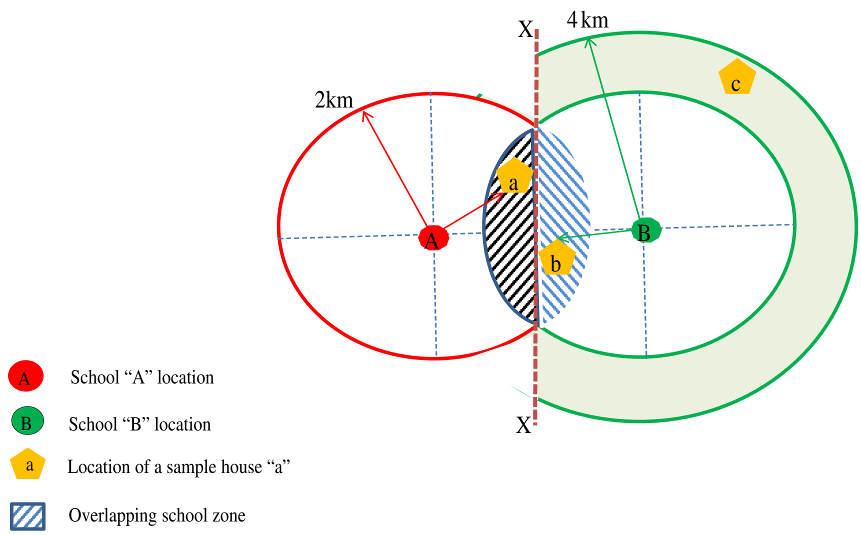


Fig. 3. Demarcation of school zone and school overlapping zone. Note: The figure illustrates the assignment of housing sample based on the home–school distance into the school zone [distance ≤ 2 km] and other control zone [2 km < distance < 4 km]. It also shows how distances of houses in the overlapping zone, i.e. houses "a" and "b" are measured in our empirical analyses.

In the Diff-in-Diff framework, we employed the treatment window "AFTER(τ)", where τ indicates the cut-off times, such that $[\tau = (-12, -6, 0)]$ denotes 12 months before the event, six months before the event, and the current relocation event, respectively. The treatment window was interacted with the school distance variable "TREAT(i)", where $[i = (1, 2)]$, such that ["TREAT(i) $\times$ After(t)"]. We used the interactive terms to test whether school distance effects were significantly capitalized into housing prices after the school relocation events at time t. The null hypothesis is not rejected if the interaction terms are not significantly different from zero, which implies that the housing purchase decisions were not affected by the school relocation events.

4.4. Descriptive statistics

We collected a total of 419,240 sample transactions of private non-landed houses and public HDB resale houses as well as data on their distances to the closest schools for the sample period spanning January 1, 1998, to December 30, 2011. Based on the home–school cut-off distance of 4000 m and the eight-quarter event window, data falling outside the spatial and time ranges was filtered. The pooled data used in our empirical analyses contains 135,788 observations. This full sample is made up of 46,655 private housing transactions and 89,133 public housing transactions. As indicated by the housing type composition, public resale housing units ("PUBLIC" = 1) constitute about 65.6% of the total sample,

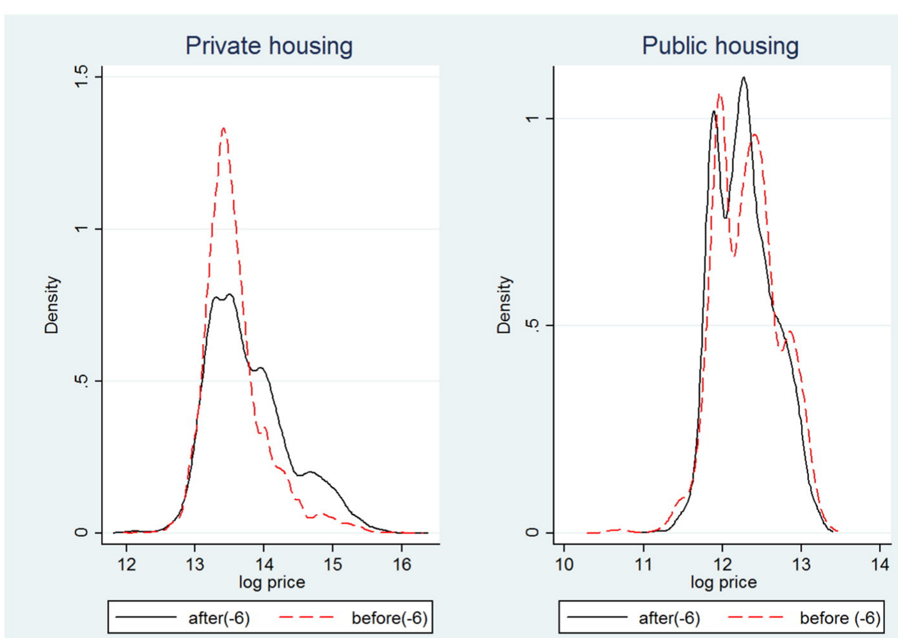


Fig. 4. Kernel density plots for private and public housing prices. Note: The figure shows the kernel density of log-housing prices for the private housing market (left-hand panel) and the public housing market (right-hand panel). Based on the treatment event is set at 6 months before the actual school relocation, the kernel density distributions for log-price before (dashed line) and after (darken line) are plotted in the above figure. The figures include only housing samples that are located within a 2 km radius from school locations.

and the remaining 34.6% is made up of private housing units ("PUBLIC" = 0). Table 3 further divides the samples by the outer 4-km boundary into new ("NEW") and old ("OLD") school zones. There were 109,748 housing transactions in the old school locations ("OLD") and 106,539 housing sales in the new school locations ("NEW") in the sample period. We further divided the transaction samples in the two school zones by the 2-km cut-off into a treatment zone (TREAT) and a control zone. In the old school zone, there were 45,258 transactions in the 2-km radius school zone, compared to 64,490 housing sales in the control zone (2-km to 4-km boundary). The new school zone also had a higher sale volume of 60,767 houses in the outer areas bounded by the 2-km to 4-km rings, compared with 45,772 housing sales in the area within 2 km from the new school.

Fig. 4 shows the kernel density plots of log-housing prices before and after the school relocation events (using six months pre-announcement as the cut-off date) for the private housing market (left panel) and the public housing market (right panel). According to the transaction samples, the prices for private houses ranged from S$442,414 (log-price = 13) to S$1,202,604 (log-price = 14.0), and the prices for public housing ranged from S$147,267 (log-price = 11.9) to S$442,414 (log-price = 13). We observed a significant shift to higher prices (above S$1,200,000) in private housing transactions after the school relocation events. The transaction volume in the public housing market remained relatively the same; however, housing prices shifted to the left after the relocation events (darkened line) relative to housing prices before the relocation events (dashed line).

Table 3 shows the descriptive statistics for empirical variables used in our empirical analyses. The mean log-price of the full housing samples is estimated at 12.770 (or the equivalent of S$462,967.40). The average log-price for private housing is estimated at 13.559 (S$867,481.10), which is much higher than the average public housing price, which is estimated at 12.356 (S$251,232.40). For the old school location, the average log-housing price is estimated at 12.810 (S$525,880.70) and 12.764 (S$450,435.10) in the treatment zone (≤2 km from school) and the control zone (2-km to 4-km zone), respectively. The average log-price for houses in the new school zone is lower, estimated at 12.796 (S$491,259.50) for the treatment zone (<2 km zone) and 12.779 (S$458,481.90) for the control zone (2-km to 4-km zone). The *t*-tests reject the null hypothesis that average prices of houses in the treatment and the control groups are indifferent, and the results are consistent for both the new and old school locations. We would conduct more robust tests in the following sections by controlling for variations in housing attributes and location characteristics in the models.

By unit size, the mean floor area ("Size") for all the sample houses is estimated at 107.394 square meters (m^2). The private housing units are larger, with an average floor area of 128.286 m^2, compared to an average floor area of 96.459 m^2 for public housing units. The variation in the floor size of the housing units is small across different zones, ranging from 104.6690 m^2 ("OLD" school control zone) to 112.782 m^2 ("NEW" school treatment zone).

For private housing units, we further divided the sample by the sale type dummies into two categories: new sale and resale. New sale and resale samples constitute the larger fraction of the private housing samples, accounting for 34.4% and 65.6% of the samples, respectively. All the public housing samples are from the resale public housing market.[18] We also used the buyer type dummy to identify whether buyers in the private houses upgraded from public housing vis-à-vis other buyers, which may include Singapore residents who live in private houses and/or foreigners. 48.4% of the private housing buyers upgraded from public housing. The average age for the full sample houses is estimated at 18.556 years. Private housing units are newer, with an average age of 4.897 years, compared to 23.070 years for the average public housing unit. The lower age figure for private housing is largely attributed to the sales of pre-completed units by developers.[19]

The mean distance of the sample houses measured as a continuous linear distance to the closest school is estimated at 3587.740 m (m) and 3254.953 m in the old and the new school zones, respectively. With a mean distance of 3097.532 m, private housing units are located closer to the old school location ("OLD") relative to public housing units, which have a mean distance of 3842.807 m. For the old school locations ("OLD"), the distance to the school before relocation is estimated at 1269.906 m and 2982.398 m for the treatment and the control zones, respectively. Following relocation, the average distance to the new school in the treatment zone is estimated at 1180.580 m, and the average distance in the control zone is estimated at 2989.638 m.

5. Empirical methodology

Using school relocation events as exogenous shocks, we tested the capitalization effects of school location on housing price using the Diff-in-Diff methodology. We used the interaction terms "TREAT(i) × AFTER| × ϕ" to test whether housing price changes after school relocation events for homes in the treatment zone within the MOE's priority allocation zone (≤1-km and 1-km to 2-km radius from the old school location) and homes outside the 2-km zone of the affected school zone. Table 2 shows that most of the schools in our sample were relocated in December and January (except for River Valley Primary) to coincide with the new school term, which usually starts in January. However, the school relocation news could have been announced during the application and allocation exercises, which are typically held before the new term in July and August. To capture the possible pre-relocation announcement effects, we used six months, denoted by "After(−6)", and 12 months, denoted by "After(−12)", as the reference dates. The log-housing price ("logprice") model is defined as:

$$\text{logprice}_{i,j,t} = \alpha_i + X'\beta_i + \delta_i \text{TREAT}(i) + \gamma_i \text{AFTER}(t) + \theta_i[\text{TREAT}(i) \times \text{AFTER}(t)] + \lambda_j + \tau_t + \varepsilon_i \quad (1)$$

where the subscript (i, j, t) indexes a sample transaction of a house i in the postal region j that was sold at time t. The vector X in the model controls for variations in housing attributes, such as unit size ("SIZE") and housing age ("AGE"). For public housing sales, we also controlled for room type using a categorical variable, HDBROOM, which identifies four room types (1 = 3-room and smaller flats; 2 = 4-room flats; 3 = 5-room flats; 4 = other bigger flats). For private housing sales, we controlled for other heterogeneity in the project type with the dummy variable "DUMCONDO", which has a value of 1 if a home is a condominium project and a value of 0 if a home is an apartment project.[20] We also controlled for the buyer type based on the buyers' home addresses, where "DUMBUYER" has a value of 1 if the buyer has a public housing address and a value of 0 if the buyer has a private housing address. We further separated private housing sales into new sales of pre-completed homes ("DUMNEW"), and sales of completed private housing units in the resale market ("DUMRES"). As public housing is restricted by the five-year minimum occupation period rule imposed by the government, all public housing transactions take place in the resale market. We also controlled for intra-sample variation using the 82

[18] The sale type dummies are not useful for identifying public housing transactions because all public housing units are sold in the resale markets. HDB housing owners are required to stay for a minimum occupation period of five years before they are allowed to sell their houses.

[19] Pre-completion sales are very common in Singapore, where developers start selling their private condominium projects before they are completed. The sale proceeds go into a project account, which can be drawn down progressively by the developer to finance construction work and reduce financing costs.

[20] Condominium projects are built on a larger plot of land with a minimum size of 0.4 ha, and no restriction is imposed on foreign ownership. Whereas, apartment projects are subject to the Residential Property Act that restrict foreigners to purchase apartments that are less than 6-storey in height.

postal sector fixed effects, λ_i, where the island is divided into 82 sectors based on the first two digits of the postal code; the fixed year effects, τ_t. α, β and θ, are regression parameters, and ε is the *i.i.d.* error term.

6. Empirical results

6.1. School relocation effects

We first ran panel regressions in Eq. (1) to test school relocation effects on housing prices in a neighborhood where a school is removed in the relocation exercise. The impact of the school relocation on housing prices is captured by the coefficient θ_i. If the school priority allocation policy matters (based on the home-distance rule), we expect a negative and significant coefficient θ_i that reflects discounting effects on housing prices for the removal of a school from the old school neighborhood. We used "TREAT(i)" and included two treatment variables, where $[i = 1]$ represents houses located within the 1-km boundary, and $[i = 2]$ represents houses located between the 1-km and 2-km boundary in the models to capture the differential effects of the prioritization rule in school allocation exercises.

Table 4 summarizes the results of the panel regressions with a fixed sector (spatial) and a fixed year effects for private housing. Three different treatment times, as represented by "After(t)", where $[t = (0, -6, -12)]$, are used to capture the differential information effects of school relocations on housing prices in the old school locations. The adjusted R^2 is estimated at 0.735 for all three models. The coefficients on the housing attributes and other housing sale covariates are significant, and the signs are consistent in all the models. Unit size ("SIZE"), condominium ("DUMCONDO"), and freehold tenure ("FREETEN") have positive effects on private housing prices, whereas other factors, such as building age ("AGE"), resale type ("DUMRES"), and public housing buyers ("HDBBUYER"), are discounted in the private housing prices.

When we examined the treatment variables, "TREAT1" and "TREAT2", we found that the proximity to school has significant and positive effects on the old school location. In Model 1, houses located within 1 km from the school and houses located between 1 and 2 km from the school are sold at premiums of 2.4% and 17.5%, respectively, compared to houses (control samples) located between 2 and 4 km from the school. The lower price premiums for houses in the 1-km zone could be caused by possible negative externalities (noise and congestion) associated with the proximity to schools. The positive school premiums are higher when the six-month and 12-month pre-relocation cut-offs are used to proxy the treatment effects. The premiums vary between 4.0% and 6.1% for the 1-km zone (Model 2) and between 19.3% and 20.5% for the 1-km to 2-km zone (Model 3), respectively. The coefficient on the "AFTER(t)" shows that housing prices increase in the post-school relocation periods, and the rates of increase range from 1.2% (Model 1) to 2.9% (Model 2).

The first interaction variable, "TREAT2 × AFTER(t)", measuring the treatment effects in the experiment shows that the relocation events have a significant and negative impact on the 1-km to 2-km school

Table 4
School relocation effects in private housing market.

Model	(1)	(2)	(3)	(4)	(5)
Event time (AFTER(t))	Moving date	6 months before	12 months before	6 months before	6 months before
Housing sale type	All	All	All	New sale	Resale
Observation	26,707	26,707	26,707	12,986	13,721
Unit size (AREA)	0.003***	0.003***	0.003***	0.002***	0.004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Building age (AGE)	−0.011***	−0.011***	−0.011***	0.001	−0.017***
	(0.000)	(0.000)	(0.000)	(0.005)	(0.000)
Condominium (DUMCONDO)	0.178***	0.178***	0.179***	0.242***	0.140***
	(0.004)	(0.004)	(0.004)	(0.007)	(0.005)
Resale (DUMRES)	−0.020***	−0.020***	−0.020***		
	(0.005)	(0.005)	(0.005)		
Buyer type (HDBBUYER)	−0.071***	−0.071***	−0.071***	−0.073***	−0.046***
	(0.003)	(0.003)	(0.003)	(0.005)	(0.004)
Freehold tenure (FREETEN)	0.254***	0.255***	0.256***	0.215***	0.263***
	(0.004)	(0.004)	(0.004)	(0.007)	(0.005)
Within 1 km school zone (TREAT1)	0.024***	0.040***	0.061***	−0.041**	0.047***
	(0.009)	(0.010)	(0.011)	(0.018)	(0.011)
1 km–2 km school zone (TREAT2)	0.175***	0.193***	0.205***	0.234***	0.184***
	(0.007)	(0.007)	(0.008)	(0.013)	(0.008)
AFTER(t)	0.012*	0.029***	0.027***	0.006	0.047***
	(0.007)	(0.006)	(0.007)	(0.010)	(0.007)
TREAT1 × AFTER(t)	−0.006	−0.029***	−0.055***	−0.035*	−0.002
	(0.010)	(0.010)	(0.011)	(0.018)	(0.011)
TREAT2 × AFTER(t)	−0.040***	−0.060***	−0.069***	−0.142***	−0.036***
	(0.008)	(0.008)	(0.008)	(0.014)	(0.008)
Constant	13.667***	13.661***	13.645***	13.648***	12.805***
	(0.072)	(0.071)	(0.072)	(0.253)	(0.063)
Adjusted R-squared	0.735	0.735	0.735	0.693	0.843
Planning sector FE	Yes	Yes	Yes	Yes	Yes
Year of sale FE	Yes	Yes	Yes	Yes	Yes

Note: The table reports the panel regression results with log-housing prices ("logprice") as the dependent variable controlling for fixed year and fixed planning sector effects. Distance is the linear distance from a house i to the nearest school measured in meter. Other control variables include housing size ("AREA"), housing age ("AGE"), housing type dummy ("DUMCONDO" = 1), if a housing sample is a condominium; and otherwise ("DUMCONDO" = 0) if it is an apartment; sale type dummy ("DUMRES" = 1), if a housing unit is sold in resale market; and otherwise ("DUMRES" = 0), if a house sample is a pre-completed unit sold by developers; buyer type dummy, "HDBBUYER" is 1, if a buyer lives in public housing unit; and 0 otherwise for non-public housing buyers; and a tenure dummy, "FREETEN" that identifies freehold tenure as 1; and otherwise 0 for tenure that are 99 years and less. TREAT1 and TREAT2 are distance dummy variables that identify housing samples in the 1 km school zone and 1 km–2 km school zone, respectively. Model (1) to (3) are estimated using the full housing samples (within 4 km boundary), but three different event times are used, which include the actual relocation date, "AFTER(t = 0)", 6 months before school relocation, "AFTER(−6)", and 12 months before school relocation, "AFTER(−12)". Models in column (4) and (5) are estimated using the new sale (DUMRES = 0) and resale housing samples (DUMRES = 1).
The standard errors are shown in parentheses. *** indicates significance at the 1% level; ** indicates significance at the 5% level; * indicates significance at the 10% level.

zone, whereas the second interactive variable, "TREAT1 × AFTER(t)", shows that the effect is negative but insignificant in the 1-km school zone. The negative signs in both the interactive terms indicate that houses in the old school zone are adversely affected by the school relocation events; and the results are consistent with the story of the distance-based school enrolment policy. However, the insignificant treatment effect in the 1-km old school zone may reflect the trade-off for the effects of noise and dis-amenities associated with being too close to schools by some families in the private housing market.[21]

When we shift the treatment date to 6 months and 12 months before the school relocation, we found that the two interaction variables, "TREAT1 × AFTER(t)" and "TREAT2 × AFTER(t)", become highly significant and negative in the models. If the school relocations are announced six months prior to the relocation, private housing prices are discounted by 2.9% and 6.0% in the 1-km school zone and 1-km to 2-km school zone, respectively. The effects are even stronger when relocation is announced 12 months in advance. Discounts to private housing prices associated with the removal of schools from the neighborhoods are estimated at 5.5% and 6.9% in the 1-km new school zone and the 1-km to 2-km school zone, respectively. The results suggest that the school relocation events could have been made known as early as six months before the actual date of the relocation to coincide with the allocation exercises usually held in July and August. Some schools may have informed parents as early as 12 months ahead of the relocation when schools conduct surveys to determine if siblings of existing students plan to enroll in the new academic term (Phase 2 A(2) as indicated in Table 1).[22]

6.2. Heterogeneity tests: new sale versus resale

Using the six months before relocation as the reference date, we further test whether the school relocation events have differential effects on housing prices in new sales by developers ("DUMNEW" = 1) and resales ("DUMRES" = 1) in the private residential markets. In the new sale market, developers typically pre-sell their units before completion, and buyers generally wait up to five years before gaining physical possession of the units. The housing prices are fixed by the developers, and there is little room for negotiation. We identified pre-completed units as the new sales group, denoted by "DUMNEW" = 1, and the sales of units with physical possession as the resale markets, denoted by "DUMRES" = 1.

Table 4 shows the panel regressions with a spatial fixed effect and a year fixed effects for the new sale market (Models 4) and the resale market (Model 5). The adjusted R^2 is 0.843 for Model 5 and 0.693 for Model 4. The control variables in the two models are significant and have consistent signs. We also found that "TREAT1" variables are significant, but have opposite signs in the new sale and resale markets. Buyers of pre-completed units pay a lower price for houses located within the 1-km radius old school zone, whereas resale houses in the same area sell at a premium. The results show that buyers will pay more for houses located outside the 1-km zone but still within the 2-km boundary to enjoy the prioritized school allocation benefits. The new sale market shows insignificant price growth after the relocation events, whereas a significant positive price trend is observed in the resale market, as indicated by the coefficient on "AFTER(−6)".

For houses within the 1-km school zone ("TREAT1" = 1), the coefficient on the interaction variable, "TREAT1 × AFTER(−6)", is negative and significant in the new sale market. The coefficient in the resale housing market is insignificant, though it has a negative sign.[23] However, we found significant negative effects associated with the school relocation events are found in both the new sale and resale housing prices in the 1-km to 2-km zone ("TREAT2" = 1). The school relocations caused the prices of new sale houses in the 1-km to 2-km school zone to decline by 14.2%, and the prices of resale houses to decline by 3.6% in the same school zone. Parents who purchased houses in the old school locations with the intention of getting their children into their school of choice through the proximity prioritization rule are likely to be disappointed by the school relocation events.[24]

Table 5
School relocation effects in public housing market.

Reference event time (After "i"=)	Moving date	6 months before	12 months before
Observation	68,507	68,507	68,507
Unit size (AREA)	0.012***	0.012***	0.012***
	(0.000)	(0.000)	(0.000)
Building age (AGE)	−0.008***	−0.008***	−0.008***
	(0.000)	(0.000)	(0.000)
HDB room type (HDBTYPE)	0.047***	0.047***	0.046***
	(0.002)	(0.002)	(0.002)
Within 1 km school zone (TREAT1)	−0.011***	−0.012***	−0.008***
	(0.002)	(0.002)	(0.003)
1 km–2 km school zone (TREAT2)	0.014***	0.013***	0.016***
	(0.002)	(0.002)	(0.002)
AFTER(t)	0.020***	0.022***	0.021***
	(0.002)	(0.002)	(0.002)
TREAT1 × AFTER(t)	−0.014***	−0.007**	−0.012***
	(0.003)	(0.003)	(0.003)
TREAT2 × AFTER(t)	−0.003	−0.001	−0.005**
	(0.002)	(0.002)	(0.002)
Constant	11.570***	11.563***	11.565***
	(0.008)	(0.008)	(0.008)
R-squared	0.903	0.903	0.903
Planning sector FE	Yes	Yes	Yes
Year of sale FE	Yes	Yes	Yes

Note: The table reports the panel regression results with log-housing prices ("logprice") as the dependent variable controlling for fixed year and fixed planning sector effects. Distance is the linear distance from a house i to the nearest school measured in meter. The control variables include housing size ("AREA"), housing age ("AGE"), and HDB room type dummy ("HDBTYPE"). TREAT1 and TREAT2 are distance dummy variables that identify housing samples in the 1 km school zone and 1 km–2 km school zone, respectively. The models are estimated using full housing samples that fall within the 4 km boundary from the old school locations, and using 6 months before school relocation as the event date, "AFTER(−6)",
The standard errors are shown in parentheses. *** indicates significance at the 1% level; ** indicates significance at the 5% level; * indicates significance at the 10% level.

6.3. Public housing market

We repeated the regressions in Eq. (1) using the public housing samples and summarized the results in Table 5. The models' goodness of fit is estimated at 0.903, which is stronger than that reported in models using the private housing samples in Table 4. The unit size ("AREA") and bigger room type ("HDBROOM") has a positive impact on public housing prices, and housing age ("AGE") has a negative impact on public housing prices. The coefficient "TREAT1" representing public housing units that are within 1-km radius from the old schools is significant and negative. Whereas, "TREAT2" has a positive and significant coefficient, which shows that public housing units in the 1-km to 2-km zone have positive premiums relative to the control samples in the old school zone. The results may imply that while families living close to

[21] The insignificant coefficient shown only in the private market may also suggest the income effects on the values of negative externalities associated with the surrounding living environment (Zheng et al., 2009).

[22] The results could not rule out the anticipation effects, because the relocation information may have been communicated to parents during the school admission exercise period in July/August, or when schools conduct survey on siblings' application, usually at the beginning of the year. However, it is difficult to determine the announcement dates.

[23] The supply story may explain the large discounting effects for the school relocation events in the new sale market relative to resale market. As new project supply (launch) is lumpy, developers are not able to change the supply of new (pre-sale) housing units after the school relocation events are announced.

[24] Parents could only use the 2-km home–school distance privilege in the primary school allocation exercise, if they purchase a unit that is expected to be completed within two years prior to their child's entry into primary one.

school enjoy proximity advantage in school admission exercises, they may also face the trade-off of negative externalities (noise and congestion), if their houses are too close to schools.[25] The positive coefficient on "After" indicates increases in public housing in both school locations after the school relocation events.

The results show that the treatment effects (interaction variables) are only significantly positive within the 1-km zone, but not significant in the 1-km to 2-km zones for the new school locations. The interaction variables show that there are significant negative effects associated with the school relocation events on public housing prices in the 1-km old school zone. The effects vary from 0.7% to 1.4% if different relocation event cut-off times are used. The relocation events have negative, insignificant effects on public housing units in the 1-km to 2-km zones if we move the window event to six months before the actual relocation. However, if the school relocation news is released 12 months ahead of the relocation, public housing units in the 1-km to 2-km zones are sold at discounts of 0.5% relative to other comparable public housing units located outside the 2-km zone (control samples). Compared to the results in Table 4, we found that welfare losses associated with school relocations for public housing residents are significant, but not as strong as the effects experienced by private housing residents. Unlike sellers in the public resale housing market, where sales are restricted to Singapore's residents (SCs and SPRs), those in the private housing market face competition from non-resident buyers and, thus, may react more strongly to school relocation events. Furthermore, compared to public housing residents, private housing residents who have higher income elasticity may react more negatively to school relocation events. More tests can be done in the future if data on buyers' profiles and family composition can be obtained.

6.4. School popularity ranking effects

We further tested whether differential discounting effects are found in relocations of popular schools relative to other schools. We first used a dummy variable, "DUMTOP50", to identify the top 50 popular schools based on a combination of the success rate in the Phase 2C intake and the academic ranking of schools as published in the popular school survey website in Singapore. We then ran the Diff-in-Diff model for the top 50 popular schools vis-à-vis those not among the top 50 popular schools and used the six-month pre-relocation date as the reference ($t = -6$). The results for the private housing market (Models 1 and 2) and the public housing market (Models 3 and 4) are reported in Table 6. The adjusted R^2 range from 0.585 (Model 2) to 0.916 (Model 4). The control variables in the two models are significant, and the signs of coefficients are consistent. In addition, we found that the 1-km and 1-km to 2-km school zones are significant and positive in both the private and public housing markets, with the exception of the public housing zone with schools that are not in the top 50 ranking (Model 4). The post-relocation market time trends, "AFTER", are significant and positive for all the models.

For the Diff-in-Diff effects, we found significant and negative effects on prices in both the private housing market (Model 1) and public housing market (Model 3) if the relocated schools are ranked in the top 50("DUMTOP50" = 1). The effects are significantly stronger in the private housing market, where prices declined by 8.5% and 12.2% for private houses located in the 1-km and 1-km to 2-km zones, respectively, relative to private houses outside the school prioritization zones (2-km to 4-km zone). The negative effects of losing a top 50 school are stronger than the earlier results of −2.9% and −6.0% for the 1-km and 1-km to 2-km zones using the full samples (Table 4). When we examined the effects of the relocation of schools that are not ranked in the top 50 in the private housing market, we found negative but insignificant coefficient on the "TREAT1 × AFTER(−6)" variable, but the effects are significant on prices of private houses located in the 1-km to 2-km school zone ["TREAT2 × AFTER(−6)"]. For the Diff-in-Diff effects in the public housing markets affected by the relocation of schools ranked in the top 50, the decline in public housing prices is significant relative to the control zones, but with a smaller magnitude estimated at 5.1% and 2.4% for the 1-km and 1-km to 2-km zones, respectively (Model 3). As in the private housing market, the popular school effects are significant in the public housing market when welfare losses are larger than −0.7%, as reported in Table 5. The results were insignificant in both treatment zones in the public housing market if relocated schools are not ranked in the top 50 (Model 4).

The popular school effects are significant in both the private and public housing markets. The relocation of top schools creates larger welfare losses to residents (discounting effects on housing prices) than the relocation of average schools. The results are also consistent with the findings in Western countries by Figlio and Lucas (2004) and Gibbon and Machin (2006), which show that popular schools generate a stronger school distance capitalization effect on housing prices than do average schools. Families are more willing to pay higher price premiums for

Table 6
School popularity effects.

Model	(1)	(2)	(3)	(4)
Private/public housing	Private	Private	Public	Public
Treatment time (After "I"=)	6 months before	6 months before	6 months before	6 months before
Top 50 schools?	Yes	No	Yes	No
Observations	16,273	10,434	12,838	55,669
Unit size (AREA)	0.005***	0.001***	0.016***	0.011***
	(0.000)	(0.000)	(0.000)	(0.000)
Building age (AGE)	−0.019***	−0.008***	−0.004***	−0.009***
	(0.000)	(0.000)	(0.000)	(0.000)
Condominium (DUMCONDO)	0.156***	0.163***		
	(0.005)	(0.006)		
Resale (DUMRES)	−0.000	−0.025***		
	(0.005)	(0.006)		
Buyer type (HDBBUYER)	−0.062***	−0.048***		
	(0.004)	(0.004)		
Freehold tenure (FREETEN)	0.256***	0.214***		
	(0.005)	(0.006)		
HDB room type (HDBTYPE)			−0.011**	0.079***
			(0.004)	(0.002)
Within 1 km school zone (TREAT1)	0.075***	0.072***	0.051***	−0.020***
	(0.011)	(0.020)	(0.010)	(0.002)
1 km–2 km school zone (TREAT2)	0.266***	0.042***	0.072***	0.003
	(0.010)	(0.009)	(0.006)	(0.002)
AFTER(t)	0.032***	0.040***	0.040***	0.020***
	(0.008)	(0.009)	(0.006)	(0.002)
TREAT1 × AFTER(t)	−0.085***	−0.007	−0.051***	0.001
	(0.010)	(0.021)	(0.012)	(0.003)
TREAT2 × AFTER(t)	−0.122***	0.055***	−0.024***	0.002
	(0.010)	(0.009)	(0.007)	(0.002)
Constant	13.174***	13.237***	11.153***	11.632***
	(0.019)	(0.150)	(0.018)	(0.024)
Adjusted R-squared	0.836	0.585	0.884	0.916
Planning sector FE	Yes	Yes	Yes	Yes
Year of sale FE	Yes	Yes	Yes	Yes

Note: The table reports the panel regression results with log-housing prices ("logprice") as the dependent variable controlling for fixed year and fixed planning sector effects. Distance is the linear distance from a house i to the nearest school measured in meter. For the private housing market (Models 1 and 2), the control variables include housing size ("AREA"), housing age ("AGE"), housing type dummy ("DUMCONDO"), sale type dummy ("DUMRES"), buyer type dummy ("HDBBUYER"), and a tenure dummy ("FREETEN"). For the public housing market (Models 3 and 4), HDB room type dummy ("HDBTYPE") is included. TREAT1 and TREAT2 are distance dummy variables that identify housing samples in the 1 km school zone and 1 km–2 km school zone, respectively. The Models are estimated using full housing samples (4 km boundary) and using 6 months before school relocation as the event date, "AFTER(−6)", Models 1 and 3 are estimated using housing samples with relocation of top 50 popularity ranking school, and Models 2 and 4 using housing samples in locations with schools outside the top 50 popularity ranking. The standard errors are shown in parentheses. *** indicates significance at the 1% level; ** indicates significance at the 5% level; * indicates significance at the 10% level.

[25] The differences in the proximity effects in the 1-km schools between the public housing market and the private market may suggest that less popular schools are found in the public housing estates.

the proximity to popular schools in Singapore in both the private and public housing markets.

6.5. Prioritization in distance-based school allocation policy

The distance-based rule gives priority to families living within 1 km from the school, followed by those living between 1 and 2 km from the school. By using only housing samples that meet the school allocation priority rule (within 2-km radius from the schools), we test if differential effects are found in the school relocation events on housing prices in the "TREAT1" zone (treatment) vis-à-vis the "TREAT2" zone (control). We ran two separate Diff-in-Diff models for the private and the public housing markets using the six-month pre-relocation date as the event date; the results are summarized in Table 7. We found that the coefficient on "TREAT1 × AFTER(−6)" is significant and negative in the old school locations in the private housing market (Model 1), but insignificant in the public housing market (Model 2). After the school relocation, private housing prices in the 1-km school zone declined by more than 4.5% relative to comparable housing prices in the 1-km to 2-km school zone. However, the differential effects between the two school zones are insignificant in the public housing market.

The asymmetric responses of private and public housing families towards the sequence of prioritization in the school allocation could be related to distributions of popular schools in the two housing estates. As fewer public housing units are located within 1-km zone from popular schools compared to private houses, private housing families are more willing to pay higher differential premiums for living in 1-km school zone relative to 2-km school zone.[26] More tests are needed to examine the behavioral differences between families in the private and public housing markets in response to the removal of a school from their neighborhoods.

In the public housing model shown in Table 7 and the earlier results shown in Table 5, we found the "TREAT1" variable to be significantly negative in all the results. The negative coefficient on the treatment variable "TREAT1" seems to suggest possible cofounding effects that could bias the prioritization effects for the 1-km zone in school allocation exercises. Public housing buildings closely sited to each other could be subject to noise and congestion externalities generated in the 1-km school zone. This could be an issue especially for families who do not have school going children. The negative externalities could bias down the distance-based prioritization effects for houses in the 1-km school zone. The distance measure could, however, also pick up accessibility premiums for houses that are near the school, which could neutralize noise and congestion externalities. We conducted more robustness tests in the following sections to separate effects associated with accessibility effects (positive) and/or noise and congestion externalities (negative) in the school allocation priority zone (within the 1-km zone).

We expected that congestion and noise externalities and accessibility premiums would only affect households that live reasonably close to the schools and that the effects could only be directly felt in the old school zone before the relocation. We further separated the housing distance into four distance dummy variables: [DIST2 = 1, if school distance ≤ 200 m; DIST3 = 1, if school distance is between 201 m and 300 m; DIST4 = 1, if school distance is between 301 m and 400 m; and DIST5 = 1, if school distance is between 401 m and 500 m]. We ran the log-housing price regression models for the old locations using only housing samples located in the "TREAT1" zone that were sold more than six months before the relocation ["AFTER(−6)" = 0]. The results in Table 8 show that the models' adjusted R2 are 0.851 and 0.904 for the private and public housing markets, respectively. The control variables are all significant and with the correct signs.

On the distance variables, we found significant negative price effects for public housing units located within the 200-m ("DIST2") boundary from the schools, an area that is most likely to be subject to the noise and congestion externalities from the schools. The DIST2 variable is negative but insignificant in the private housing market. We also found that, for public housing units located between 201 m and 300 m from the schools ("DIST3"), and private houses located between 301 m and 400 m from the schools ("DIST4"), are sold at significant premiums of 4.2% and 6.5%, respectively, relative to other houses in the 1-km school zone. In these two distance ranges, families could enjoy the proximity to the schools and yet be situated far enough to be insulated against the noise and congestion from school activities. The results have significant implications for studies that use school distance proxy to show the negative relationships between house price and house-to-school distance, and the distance effects could be biased if these two distance related effects are not taken into account.

6.6. Relocation effects in new school neighborhoods

We next test the school relocation effects on housing prices in the new school locations. The relocation of a school into a new neighborhood could attract with it new developments and amenities to the surrounding area, which could have positive effects on housing prices in the neighborhood. Moreover, in the selection of school location, the government may not choose to relocate schools to neighborhoods with high land costs from public finance considerations. The above

Table 7
Prioritization in school allocation effects.

Model	(1)	(2)
Housing type	Private	Public
Reference event time (After "*i*"=)	6 months before	6 months before
Observations	3341	10,591
Unit size (AREA)	0.004***	0.012***
	(0.000)	(0.000)
Building age (AGE)	−0.013***	−0.006***
	(0.001)	(0.000)
Condominium (DUMCONDO)	0.086***	
	(0.010)	
Resale (DUMRES)	−0.007	
	(0.011)	
Buyer type (HDBBUYER)	−0.042***	
	(0.007)	
Freehold tenure (FREETEN)	0.233***	
	(0.011)	
HDB room type (HDBTYPE)		0.071***
		(0.004)
Within 1 km school zone (TREAT1)	−0.023	−0.009**
	(0.022)	(0.004)
AFTER(t)	0.074***	0.009**
	(0.014)	(0.004)
TREAT1 × AFTER(t)	−0.045**	0.005
	(0.022)	(0.005)
Constant	12.856***	11.393***
	(0.238)	(0.030)
Adjusted R-squared	0.842	0.907
Planning sector FE	Yes	Yes
Year of sale FE	Yes	Yes

Note: The table reports the panel regression results with log-housing prices ("logprice") as the dependent variable controlling for fixed year and fixed planning sector effects. Distance is the linear distance from a house *i* to the nearest school measured in meter. For the private housing market (Models 1 and 2), the control variables include housing size ("AREA"), housing age ("AGE"), housing type dummy ("DUMCONDO"), sale type dummy ("DUMRES"), buyer type dummy ("HDBBUYER"), and a tenure dummy ("FREETEN"). For the public housing market (Models 3 and 4), the HDB room type dummy ("HDBTYPE") is included. TREAT1 is a distance dummy variables that identify housing samples in the 1 km school zone. The Models are estimated using housing samples that fall within the 2 km school boundary, and using 6 months before school relocation as the event date, "AFTER(−6)".
The standard errors are shown in parentheses. *** indicates significance at the 1% level; ** indicates significance at the 5% level; * indicates significance at the 10% level.

[26] The income effects could also possibly explain the asymmetric responses with respects to the sequence in prioritization in the school admissions.

Table 8
Other distance-related effects within 1 km school zone.

	(1)	(2)
	Private	Public
Reference event time (After "*i*"=)	6 months before	6 months before
Observation	877	4219
Unit size (AREA)	0.004***	0.008***
	(0.000)	(0.000)
Building age (AGE)	−0.003**	−0.011***
	(0.001)	(0.000)
Condominium (DUMCONDO)	0.101***	
	(0.017)	
Resale (DUMRES)	−0.048**	
	(0.021)	
Buyer type (HDBBUYER)	0.230***	
	(0.022)	
Freehold tenure (FREETEN)		0.128***
		(0.008)
DIST2	−0.036	−0.039***
	(0.046)	(0.009)
DIST3	0.027	0.042***
	(0.036)	(0.009)
DIST4	0.065*	0.002
	(0.035)	(0.010)
DIST5	−0.126***	−0.016**
	(0.030)	(0.007)
Constant	12.690***	11.257***
	(0.219)	(0.125)
Adjusted R-squared	0.851	0.904
Planning sector FE	Yes	Yes
Year of sale FE	Yes	Yes

Note: The table reports the panel regression results with log-housing prices ("logprice") as the dependent variable controlling for fixed year and fixed planning sector effects. Distance is the linear distance from a house *i* to the nearest school measured in meter. For the private housing market (Models 1 and 2), the control variables include housing size ("AREA"), housing age ("AGE"), housing type dummy ("DUMCONDO"), sale type dummy ("DUMRES"), buyer type dummy ("HDBBUYER"), and a tenure dummy ("FREETEN"). For the public housing market (Models 3 and 4), the HDB room type dummy ("HDBTYPE") is included. The housing distance are divided into four categories: [DIST2 = 1, if school distance ≤ 200 m; DIST3 = 1, if school distance is between 201 m and 300 m; DIST4 = 1, if school distance is between 301 m and 400 m; and DIST5 = 1, if school distance is between 401 m and 500 m]. The Models are estimated using housing samples that fall within the 1 km school boundary, and using 6 months before school relocation as the event date, "AFTER(−6)".
The standard errors are shown in parentheses. *** indicates significance at the 1% level; ** indicates significance at the 5% level; * indicates significance at the 10% level.

Table 9
Effects of School Relocation in New School locations.

Model	(1)	(2)	(3)	(4)
	Private	Private	Public	Public
Reference event time (After "*i*"=)	Moving date	6 months after	Moving date	6 months after
Observations	9508	9508	31,120	31,120
Unit size (AREA)	0.005***	0.005***	0.009***	0.009***
	(0.000)	(0.000)	(0.000)	(0.000)
Building age (AGE)	−0.020***	−0.020***	−0.010***	−0.010***
	(0.000)	(0.000)	(0.000)	(0.000)
Condominium (DUMCONDO)	0.155***	0.155***		
	(0.006)	(0.006)		
Resale (DUMRES)	0.001	0.001		
	(0.007)	(0.007)		
Buyer type (HDBBUYER)	−0.058***	−0.059***		
	(0.006)	(0.006)		
Freehold tenure (FREETEN)	0.284***	0.283***		
	(0.006)	(0.006)		
HDB room type (HDBTYPE)			0.099***	0.100***
			(0.002)	(0.002)
OVERLAP	0.160***	0.146***	−0.020***	−0.017***
	(0.012)	(0.011)	(0.002)	(0.002)
AFTER(t)	0.017	−0.024	0.016***	−0.011***
	(0.017)	(0.015)	(0.003)	(0.003)
OVERLAP × AFTER(t)	−0.010	0.016	0.006**	−0.002
	(0.014)	(0.014)	(0.003)	(0.003)
Constant	12.781***	12.836***	11.802***	11.869***
	(0.074)	(0.073)	(0.012)	(0.012)
Adjusted R-squared	0.849	0.849	0.899	0.899
Planning sector FE	Yes	Yes	Yes	Yes
Year of sale FE	Yes	Yes	Yes	Yes

Note: The table reports the panel regression results with log-housing prices ("logprice") as the dependent variable controlling for fixed year and fixed planning sector effects. Distance is the linear distance from a house *i* to the nearest school measured in meter. For the private housing market (Models 1 and 2), the control variables include housing size ("AREA"), housing age ("AGE"), housing type dummy ("DUMCONDO"), sale type dummy ("DUMRES"), buyer type dummy ("HDBBUYER"), and a tenure dummy ("FREETEN"). For the public housing market (Models 3 and 4), the HDB room type dummy ("HDBTYPE") is included. "OVERLAP" is a dummy variables that identify housing samples that are located in the area within 2 km from both the new and old school locations. The Models are estimated using housing samples that fall within the 2 km boundary from the new school location, and two event dates are used, which include the relocation date, "AFTER($t = 0$)", and 6 months after school relocation, "AFTER(+6)".
The standard errors are shown in parentheses. *** indicates significance at the 1% level; ** indicates significance at the 5% level; * indicates significance at the 10% level.

factors could cause endogeneity to the school distance and home price relationships in the new school location. We use the overlapping school zone ("OVERLAP"), where schools are relocated not more than 2 km from the old school boundary in our experiment, and test the price changes of houses in this zone relative to other houses in the 2-km new school zone. By using only housing samples within the 2-km boundary from the school zone ("DISTANCE <= 2000 m"), we may reduce possible endogeneity problems related to new amenities and also school location selection, since price changes that are unrelated to school admission prioritization advantage are likely to have the same impact on both the overlapping and new school (2-km) zone.

Given that the school allocation priority in the overlapping zone ["OVERLAP" = 1] has not been changed before and after the school relocations, we expect the relocation events to only increase housing prices in the new school location outside the overlapping zone. Therefore, we should expect the price gap between houses in the overlapping zone, "OVERLAP", and the new school zone, "TREAT1 and TREAT2", to disappear or become narrower, if new schools increase values of houses in the school zone. We used the actual relocation event date ("AFTER($t = 0$)"), and the six-month post-relocation event date ("AFTER(+6)"), as our reference to test for time-related effects in the new school locations.

The results for the private (Models 1 and 2) and public housing (Models 3 and 4) models are summarized in Table 9, and their adjusted R^2 were estimated at 0.849 and 0.899, respectively. The control variables, except for "DUMRES" in the private housing model, are all significant and with the correct signs. The coefficients on "OVERLAP" are significant, but with positive signs for the private housing markets and negative signs for the public housing markets. The results can be interpreted as indicating that new schools are being relocated to private housing neighborhoods, where housing prices are lower than those in the original school locations. The time trends after the school relocation events are not significant in private housing markets, but are significantly different at the relocation period and the six-month post-relocation period.

The interaction variables, "OVERLAP × AFTER(t)", that capture the treatment effects are insignificant in all the three models, except for the public housing model with the event time set at the actual relocation time, "AFTER(0)". The coefficients that are not significantly different from zone supports the hypothesis that school relocations increase housing prices in the new school zone neighborhoods (within the 2-km zone), causing the price gaps between overlapping zones and new school (priority) zones to narrow or disappear. Based on the above results, we can infer that the welfare gains associated with new school relocations are significant in both the private housing and public housing markets. The school relocation effects on public housing price changes are only shown six months after the treatment event in the new school zone.

7. Conclusion

Families' Tiebout sorting into a neighborhood with good schools causes housing price in the school zones to increase. Some studies link the positive capitalization effects with school input factors, like school resources, teaching quality, peer effects and ethnic composition; others argue that parents pay premiums for school outputs, hoping that their children could benefit academically in good schools. Many studies in the US have used school redistricting and policy changes that affect ethnic composition in school as exogenous shocks in the tests for the school capitalization effects on housing prices.

Comparable studies on school capitalization effects are scarce in the Asian context, though many Asian families place strong emphasis on children education. This study uses school relocation events and the unique 2 km home–school distance-based priority allocation rule in Singapore for the periods from 1999 to 2009 to test the school capitalization effects. We find that school relocation events cause significant price declines of 2.9% and 6.0% for private houses located within 1-km zone and in 1-km to 2-km zone from the old school zone, respectively, when the school relocation news were revealed 6 months before the relocation. Larger price declines of 5.5% and 6.9% associated with the loss of a school are found for houses located the 1 km and 1 km to 2 km from the school locations, respectively, when the school relocation events were revealed 12 months earlier. The effects of school relocation are more strongly felt in the developers' sale markets than in the resale private housing markets. In the public housing market, we find that the school relocations cause significant housing prices within 1-km radius from the old school locations to decline by between 0.7% and 1.4%.

The school popularity effects were found in the school relocation experiment. In the private housing market, the loss of a top 50 ranking school could cause housing prices to decline by 8.5% and 12.2% for the 1-km and 1-km to 2-km old school zones, respectively, 6 months before of the relocation events. Public housing prices in the 1-km and 1-km to 2-km old school zone decline by 5.1% and 2.4%, respectively. We next use houses in the "overlapping" school zone as the control group to test if price gap between houses in this region and those located within 2-km school but outside the overlapping zone has disappeared after the school relocation events. We find that the new school relocations increase housing price in new school zone in both the private and the public housing markets. However, price increase in the public housing market is lagged by 6 months, and the price gap between the overlapping new school zones disappears only after 6 months of school relocations. We also conducted various heterogeneity tests on the economic values associated with school distance prioritization privilege using housing samples in new sale versus resale, private versus public housing markets, and the popular school effects. We also test effects of different prioritization order in the school allocation privilege using houses in 1-km zone versus houses in 2-km zone.

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