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Demand Restrictions and Asymmetric Risk Behaviors

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The government of Singapore imposed two rounds of demand restrictions in 2010 and 2013, respectively, which prohibited private housing owners from concurrently owning both a private housing unit and a public housing flat. These restrictions curb speculative and investment activities, but do not deter public housing owners from upgrading to private housing. Using private housing transaction data between 2005 and 2015, we find that the demand shocks in 2010 and 2013 caused a significant reduction of 2.4% and 1.8% in the transaction prices of investors relative to those of the owners, respectively, *ceteris paribus*. Larger price declines are observed in investment sales in the submarkets, such as the core central region, and resale, moderate-to-high end, and large unit markets. The results show that when the housing market is volatile, risk averse investors are found, and owners move up the “quality” curve by upgrading their home.

Keywords

Demand Restrictions, Risk Aversion, Government Intervention, Private Housing Market, Investors and Owner

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1. Introduction

Zoning regulations that restrict housing supply cause housing price increases in some of the US cities (Glaeser and Gyourko, 2003). These supply-side restrictions widen the gap between housing prices and replacement costs. Therefore, some researchers have advocated for relaxing zoning restrictions to solve housing affordability problems in some of the US cities with high housing prices (Glaeser and Gyourko, 2003). However, the effects of supply-side policies are limited in many Asian cities that are compact and densely populated. Governments of these Asian countries are more inclined to use demand-side restrictions to cool overheating housing markets (Sun et al., 2017).

In Singapore, there is a dual housing market structure that consists of a public housing market and a private housing market. The former provides housing for over 80% of the residents. The Singaporean government sells new public housing flats to Singapore citizens (SCs) at concessionary prices. There is also a secondary market, where public housing flats can be resold by SC owners, but only to other buyers, who must also be SCs and Singapore permanent residents (SPRs). The private housing market is a *laissez-faire* marketplace, where private developers acquire land, build private housing units, and sell them at market prices to local and foreign buyers. Private housing buyers could also freely buy and sell their private housing units in the secondary market, with the exception that foreigners are not allowed to own landed houses in Singapore. The government has imposed differential policies that target housing purchase activities by locals and foreigners, for example, stamp duties are levied at differential rates for local and foreign buyers.

The private housing market in Singapore has witnessed a strong recovery from the trough in the second quarter (2Q) of 2009. The private residential property price index published by the Urban Redevelopment Authority (URA) shows a year-on-year increase of 38.2% between 2Q2009 and 2Q2010. The Singapore government introduced a series of intervention measures between 2009 and 2013 to cool the market. One of the measures was to restrict demand, or more specifically, investment demand, by prohibiting concurrent ownership of a private unit and a (resale) public housing unit. In 2010, private housing owners could no longer purchase resale public housing flats, with the exception of public housing owners (including SCs and SPRs).¹ A stricter policy was then implemented in 2013 which further prohibited SPRs from holding resale public housing flats for investment purposes, and only SCs who own and stay in their public housing flats for more than 5 years are allowed to buy a second private housing unit for investment purposes. Although the 2010 and 2013 policies only target the public housing market, the demand curb is expected to have significant spill-over effects if public housing owners avoid investing in the

¹ To be eligible to purchase private housing units, public housing owners must live in their public housing unit for at least 5 years.

private housing market. The private housing price index in Figure A1 shows that after the 2013 policy was implemented, the private housing market of Singapore reverted the upward trends that had persisted for the 5 years between 2009 and 2013. The same trend is also observed in the public housing market as in Figure A2.

Policies that restrict demand are not unique to Singapore; the Chinese government uses different forms of demand restrictions to dampen the overheating of the housing markets in Beijing. Administrated through the “*hukou*” system² (residence registration), non-Beijing residents are not allowed to buy houses in Beijing, whereas Beijing residents are banned from buying a second and more houses for investment purposes effective 30 April 2010. Sun et al. (2017) show that the demand-restraining measures cause the housing prices in Beijing to go down by 17% to 32% and reduced the price-to-rent ratios by 23% to 29%. The housing transaction volume in Beijing has dropped by more than half after imposing the demand restrictions.

However, the demand restriction policies in China and Singapore are fundamentally different. While the policy in Beijing excludes housing purchases by non-Beijing residents and Beijing-based investors, the policies in Singapore prohibit policy unconstrained private investors including SPRs from buying public housing for investment purposes, but allow public housing owners to upgrade to the private housing market. Public housing buyers who buy private housing for their own occupation would not be forced to sell their public housing unit if they have lived there for more than five years. As most of these public housing owners are financially constrained³, they are unlikely to keep their public housing unit when upgrading to a private housing unit, although they are not bound by concurrent ownership rules. This group of buyers is widely known as “public housing upgraders”, or more specifically, “Housing and Development Board (HDB) upgraders” as they are known in the local context.

After the implementation of the demand restriction policies, policy unconstrained private investors are prevented from buying public housing for investment purposes; they can only invest in the private housing market, which has become more volatile after several rounds of interventions that have taken place since 2010. The concurrent policies cleanly separate the public housing market, which is purely for owner occupation purposes, from the private housing market, which serves both the consumption (own occupation) and

² This “*hukou*” system causes rent seeking among some Beijing residents, who resort to using “fake divorces” to bypass the restrictions on home purchases. Some Chinese couples fabricate a “divorce” and transfer the home-ownership rights to their spouse, so that they can buy a second apartment (Fung, 2013).

³ The income ceiling to apply for new public housing flats has been raised twice in a short span of 5 years, first from S\$8000 to S\$10,000 (6610 USD to 8265 USD) in August 2011, and subsequently to S\$12,000 (8890 USD) in August 2015.

investment needs of buyers. With the segmentation of the two housing markets, together with the home address identification of the buyers, we can better identify those who are housing upgraders (policy constrained buyers) from investors (policy unconstrained buyers) in the private housing market. There is a group of unconstrained private buyers who are not investors, but sell their existing house and upgrade to a private house. This group of private home owners, if not identified in our sample, could lower our estimations, such that the estimated negative coefficients reflect the lower bound effects of the demand restriction policies.

Unlike macro-prudential measures and transaction taxes that are applied with less discrimination across the board, the concurrent policies curb the investment activities of policy unconstrained investors without dashing the aspirations of Singaporeans to upgrade. Using the private housing market as a natural experiment, we empirically test if the concurrent housing restriction policies have achieved the intended objectives of curbing investment demand. Our hypothesis is that if the policies work, they should only adversely impact the demand of the policy unconstrained investors, and have no impact on the decisions of policy constrained buyers to upgrade to a private housing unit. An owner-buyer is defined as a buyer who purchases his/her private housing unit for his/her own-occupation. This buyer is usually financially constrained, so he/she will sell his/her public housing flat and use the cash proceeds to buy a new private housing unit. However, an investor is not financially constrained; he/she buys a new private housing flat for investment, while keeping his/her current housing unit for occupation. Based on the home address of the buyers, we sort the sample buyers in the private housing market into a group of policy unconstrained buyers (investors) (the treatment group) and a group of policy constrained buyers (homeowners) (the control group).

Based on a sample of private housing transaction data in Singapore, we find significant evidence of differential responses to the policy shocks between the two groups of private housing buyers by using a difference-in-differences (DID) framework. Our results show that investors (policy unconstrained buyers) pay 2.4% lower price for private housing purchases relative to owner occupiers (policy constrained buyers) in response to the 2010 policy, and pay 1.8% lower in response to the 2013 policy. The policies seem to adversely impact only the demand of private investors, but do not affect the private housing demand of owners.

Our explanation for the results is as follows: in a rising market, investment demand drives up prices and crowds out policy constrained buyers (owners) in the private housing market where new supply is inelastic. When the market sentiment becomes negative, risk-averse investors reduce their expected purchase price in the private market. However, policy constrained buyers (owners), who have reaped some gain when they sell their subsidized (public) housing unit, are less risk-averse and thus less price sensitive in volatile markets

relative to investors. When investors reduce investment purchases in the private housing markets, the policy constrained buyers (owners) fill in the gap left behind by the investors. The intervention measures cause relatively large price declines in transactions of private investors, and the impact is cushioned by the demand of owner-buyers without which private housing prices could have had declined even more rapidly after the shocks.

In addition, we empirically test the differential responses of both policy constrained and unconstrained buyers to the policy shocks, and also for heterogeneity of the impact across different market segments. It is hypothesised that public housing owners, who enjoy capital gains when selling their existing public housing unit, have lower risk-aversion, which in turn, increases their mobility compared to other buyers, who do not enjoy capital gains. We find that the demand restrictions create stronger negative price effects in the resale market (completed houses) relative to the new sale (houses under construction) market. Owner-buyers are more likely to receive a bargained price from individual sellers (including private housing investors), who attempt to reduce losses in a down market, compared to developers. Owner-buyers purchase more houses in the core central region (CCR) than in the fringe region and more large housing units than small “shoe-box” units, and there are more owner-buyer transactions in the moderate to high-price segments than the low-price segment of the markets.⁴ They move up the “quality” curve more quickly in the mobility process (via housing consumption) without having to pay significantly higher prices after the policy shocks. Therefore, we observe stronger price declines in investment purchases than owner-buyer purchases after the policy shocks in 2010 and 2013.

This study hopes to make two contributions, directly or indirectly, to the housing literature. First, we find empirical evidence to show that curbs on the demand of investors could reduce friction in the housing market, which in turn, increases the upward mobility of homeowners. Second, the study shows how policy treatment could ease the risk-aversion of home buyers, which adds new findings to the previous literature that has mainly focused on the risk-aversion behavior of sellers (Genesove and Mayer, 2001).

The rest of this paper is organized as follows: Section 2 reviews the related literature. Section 3 provides an overview of the Singapore housing market, and the demand-side restriction policies. Section 4 covers the data sources and the empirical methodology. Section 5 presents and discusses the empirical results. Section 6 concludes the paper.

⁴ According to the definition by the Redevelopment Authority (URA), the core central regions comprise postal districts 9, 10, 11, Downtown Core and Sentosa. The fringe region includes the remaining areas.

2. Literature Review

Housing is both a consumption and an investment good (Kraft and Munk, 2011). The wealth effects created by owning housing assets influence household decisions in consumption and precautionary saving (Gan, 2010; Chen et al., 2018). In the housing literature, there are three broad hypotheses that predict a positive price-volume relationship, which include down-payment constraints (Fuster and Zafar, 2016; Stein, 1995; Ortalo-Magne and Rady, 2004, 2006; Zhang et al., 2015), loss aversion (Anenberg, 2011; Bokhari and Geltner, 2011; Genesove and Mayer, 1997, 2001), and search hypotheses (De Wit et al., 2013; Wheaton, 1990). While most studies find evidence of a positive price-volume in up markets, few studies have, however, examined the investment and consumption activities in down markets.

Several macro-studies find evidence that households cash out price gains in starter homes and use the proceeds to pay for the down-payment of larger houses. The liquidity-induced upward mobility generates positive price and sales turnover relationships in housing markets (Hort, 2000; Leung et al., 2002; Andrew and Meen, 2003; Leung and Feng, 2005). There is similar macro-evidence in the Singapore housing markets that show the active upward mobility activities of owners who realize significant housing gains by selling their starter (public) house (Ong, 2000; Bardhan et al., 2003; Edelstein and Lum, 2004; Lee and Ong, 2005; and Sing et al., 2006). A study by the Singapore Department of Statistics published in March 2006 shows that more than 62% of Singaporean households moved upward to larger houses between 1995 and 2005. Unlike countries with large hinterlands such as the US (Hughes and McCormick, 1981, 1985(a), 1985(b), 1987; Clark and Onaka, 1983; Henley, 1998; Ortalo-Magne and Rady, 2006), changing labor market conditions are unlikely to have the same effects on housing mobility in the small island state of Singapore.

In China, the government uses the *hukou* system to exclude non-residents from buying houses and prevent residents from buying a second house for investment purposes in Beijing. Sun et al. (2017) show that the policies cause prices and transaction volumes to drop significantly thus restoring stability to the housing markets in Beijing. Unlike Beijing, our results show that the demand restrictions generate an asymmetric response between buyers and investors. The demand gap left behind by investors could be filled by owner-buyers, and the restrictions cause a shift in demand from one group of (policy unconstrained) buyers to another group of (policy constrained) buyers.

Given that housing goods are indivisible and fixed in location, Fu (1995) argues that households use a “moving” process to discretely smooth out inter-temporal housing consumption. Households adjust their housing consumption by replacing their current house with a larger house or investing in other properties. The mobility process improves the match between consumption preference and

supply of housing goods, and thus reduces social costs of providing housing goods to households. Tu et al. (2009) show that in falling markets, housing price volatility could hold back sellers from deciding to sell houses. However, our results show otherwise; owners are able to move up the housing ladder and also the housing quality curve more quickly in down markets, when owner-buyers face relatively weaker crowding out effects by investors.

The studies by Genesove and Mayer (2001) and Anenberg (2011) are a few of the studies that find evidence of loss aversion of sellers in housing markets. They show that loss-averse sellers have relatively unrealistically high price expectations in down markets, where they set a high asking price, and attain a sale price that is close to their asking price, but take a longer time to sell their house. They also show that investors are more loss-averse than homeowners, who hope to sell their loss-making house as quickly as possible in down markets.

Our results, however, show a differential risk-aversion attitude between investors and owner-buyers. We show that more risk-averse investors pay lower private housing prices relative to owner-buyers during a period of negative shocks. The effects are stronger in resale markets (units sold by individual sellers/investors), which may suggest that investors are more willing to take a smaller loss by selling houses to owners-buyers compared to other investor-buyers. More future empirical tests subject to data availability could be conducted to further examine whether the extent of housing wealth accumulated by owners could affect their private housing purchases, relative to private investors who do not have access to public housing wealth.

3. Singapore Housing Markets

Singapore has a dual housing market structure that consists of a public and a private housing market. The former meets the housing needs of approximately 82.4% of SCs and SPRs (Department of Statistics, 2019). The HDB, which is the government housing agency, builds and sells new public housing flats at subsidized prices (commonly known as “built to order” (BTO) flats⁵) to SCs who meet their eligibility criteria, which include forming a family nucleus and subjecting SCs to a monthly income ceiling of S\$12,000 (8,890 USD) per household.⁶

⁵ BTO refers to the flat allocation system adopted by the HDB since 2001 and used to represent new flats built by the HDB. In the system, construction of new public housing projects will only commence after receiving at least 70% of the applications for the new flats.

⁶ The income ceiling for BTO flats has been raised twice in a short span of 5 years; first from S\$8,000 to S\$10,000 (6610 USD to 8265 USD) in August 2011, and subsequently to S\$12,000 (8890 USD) in August 2015.

In addition to the primary public housing market, there is a co-existing secondary resale market to facilitate the buying and selling of public housing flats by SCs and SPRs at open market prices. BTO flat owners are required to meet the minimum occupation period (MOP) of 5 years before they are allowed to sell their flat to SCs and SPRs in the resale public housing market.⁷ SC and SPR buyers in the resale public housing market are not subject to the income ceiling criterion. SC owners are not allowed to sell their public housing flat to foreigners, but can rent their flat to foreigners.

The private housing market is a *laissez-faire* market that includes landed properties (such as detached, semi-detached and terrace houses) and non-landed properties (such as apartments and condominiums). Landed properties are expensive in Singapore and beyond the reach of most Singaporeans. Under the Residential Property Act, foreigners are not allowed to buy landed houses, except for those in a small pocket of designated areas on Sentosa island. Non-landed private houses form the second largest housing segment after public housing. The statistics of the Urban Redevelopment Authority (URA) show that ownership rates of non-landed private housing have increased from 6.5% in 2000 to 11.5% in 2010.

Condominiums and apartments are the two types of non-landed housing built and sold by private developers in Singapore. The former need a minimum land size of 0.4 hectares and usually come with a full range of services and facilities including security, parking facilities, landscaped gardens, and recreational facilities such as swimming pools, barbeque pits, and tennis courts among others. However, apartments are usually standalone developments built on smaller land parcels (less than 0.4 hectares) with limited facilities. While there is no restriction on foreigners for buying condominiums, they are not allowed to buy apartments of less than 6 stories in height under the Residential Property Act.

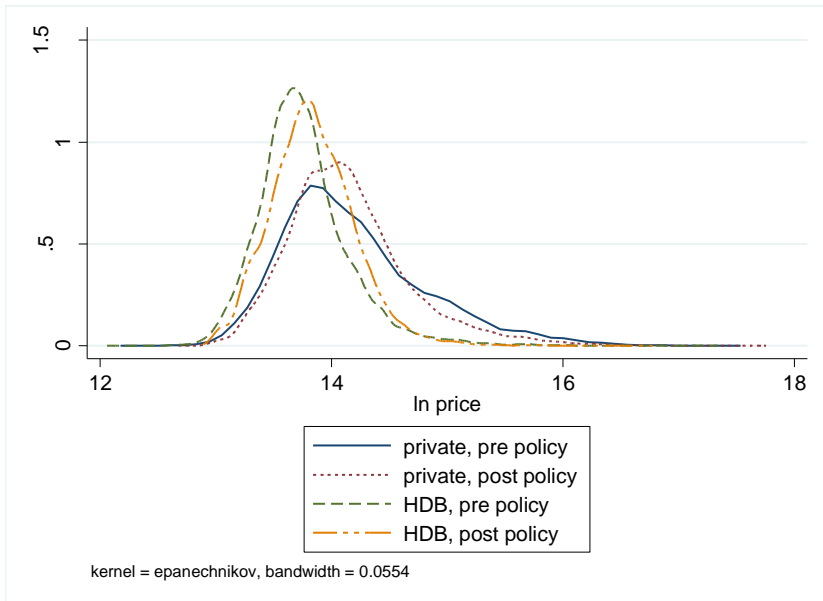
The non-landed housing markets are highly heterogeneous both in terms of pricing and quality. There is a wide variety of non-landed housing that ranges from luxury units to mass-market private units. While the former appeal to high-income investors, the latter attracts buyers who are public housing flat residents (Sing et al., 2006). This group of buyers is also referred to as “*HDB upgraders*”.

Figure 1 shows the kernel density plots of the transaction prices of private housing investors (treatment) and public housing owners (control) in the pre- and post-2010 policy periods. The pre- (dashed line) and post-policy (dash-dotted line) purchasing price kernels shift to the right for the transactions of public housing owners. Parallel shifts, together with an increase in the mean of the logarithm of price, are probably related to the upgrading of public housing

⁷ The date of key collections is recognized by the HDB as the official reference date of the sale of flats (Housing & Development Board, 2019).

owners to the private market. The kernel density lines for the private housing owners show patterns that are different from the parallel shift observed in the price kernels of public housing owners. We observe significant changes in the price kernels of private housing owners in the pre- and the post-policy periods (from the bold pre-policy line to the dotted post-policy line). The demand restrictions increase the density in the low to moderate price ranges for investors (between S\$0.98 million and S\$1.47 million (710,000 to 1.06 million USD)), and reduce the density in the high price range (above S\$1.98 million (1.43 million USD)).⁸

Figure 1 Kernel Density Plot of Log-Transaction Prices



Notes: The figure shows four kernel density plots for private housing prices, in which two are for public housing owners and two for private housing owners. The dashed line represents prices of public housing owners in the pre-policy period, and the dash-dotted line shows the post-policy prices for public housing owners. Similarly, the pre- and post-policy private housing prices of private housing owners are represented by bold and dotted lines, respectively. The policy is the 2010 policy.

⁸ S\$0.98 million (710,000 USD) is estimated as the exponential of 13.8 (the lower intersection of the bold and dotted lines), S\$1.47 million (1.06 million USD) is estimated as the exponential of 14.2 (the point that corresponds to the peak of the bold line), and S\$1.98 million (1.43 million USD) is estimated as the exponential of 14.5 (the upper intersection of the bold and dotted lines). The first two numbers are lower than the mean price of S\$1.49 million (1.03 million USD) and represent low-to-moderate priced houses.

Demand Restriction Policies in Singapore

There have been nine rounds of anti-speculation measures introduced between 14th September 2009 and 9th December 2013. The government of Singapore uses macro-prudential controls (including loan to value (LTV) ratio, mortgage servicing rights (MSRs) and total debt service ratio (TDSR)) to limit excessive bank loans for housing buyers, and also increases transaction costs in housing transactions by imposing a seller's stamp duty (SSD) and additional buyer's stamp duty (ABSD).⁹

On 30 August 2010 and 12 January 2013, two rounds of demand restrictions were introduced by prohibiting the concurrent ownership of private housing unit and public housing flat by Singaporean residents (hereafter referred to as "the 2010 policy" or "the 2013 policy", respectively).¹⁰ These two policies are used in our policy experiment in this study.

Prior to the 2010 policy, private housing owners could still purchase public housing flats from the resale (secondary) market, even if they fail to meet the eligibility criteria of the HDB. The new concurrent ownership policy that took effect after 30 August 2010 banned private housing owners from buying resale public housing flats, while keeping their private housing units for investment purposes. They are forced by the new policy to sell their private housing unit within 6 months after buying a resale public housing flat. However, the 2010 policy does not affect public housing owners (both SCs and SPRs); that is, if they have met the 5-year MOP requirement¹¹. They are also not forced to sell their public housing flat when buying a second private housing unit for investment purposes.

On 12 January 2013, the concurrent ownership policy was further extended to prohibit SPRs from concurrently owning private properties. Only SC public housing owners can buy a second private housing unit for investment purposes after fulfilling the 5-year MOP requirement. These two policies restrict SC and

⁹ The Monetary Authority of Singapore (MAS), the de-facto Central Bank of Singapore, imposes varying LTV ratios on first, second, and third property purchases secured by private bank loans. MAS also controls the total borrowing limit through TDSRs, which cap the debt service of aggregate loans by individual borrowers to 60% of their income. For public housing buyers, a mortgage service ratio of 30% is imposed on private bank loans.

¹⁰ The third round of cooling measures includes other measures to further reinforce the earlier two rounds of policy interventions: (1) extending the imposition period of the SSD from 1 year to 3 years; (2) lowering the LTV ratio limit from 80% to 70%; and (3) increasing upfront cash payments from 5% to 10% for the second property purchase.

¹¹ After 2010, the MOP was extended from 3 to 5 years, which means that public housing flat owners are no longer allowed to sell their public housing flats within a period of 5 years.

SPR private housing owners from buying a second private housing unit for investment purposes, but not public housing owners from upgrading to private housing units.

4. Data and Empirical Methodology

4.1 Data Source

We obtain non-landed private housing transaction data from the Real Estate Information System (REALIS) database published by the Urban Redevelopment Authority (URA) for a 10-year period that spans from September 2005 to August 2015 for our empirical analyses. We exclude 447 en bloc sales which involve more than one owner who come together to collectively sell the potential development rights of land. The final sample includes 201,774 non-landed private property transactions, which comprise 66% condominiums and 34% apartments. The data contain transaction details, such as floor level, unit size, property type, purchaser indicator, lease tenure, postal code, and postal sector.

Table 1 shows the descriptive statistics of key variables used in our analyses (descriptions of the variables are given in Appendix B). The average transaction price adjusted by the consumer price index (CPI) (with reference to the price in the first quarter (Q1) of 2014) is estimated at S\$1,492,146 (1,079,592 USD). Based on an average unit size of 112.5 square metres (sqm), the average unit (per sqm) price is estimated to be S\$13,263.50 (9596 USD). Private homeowners make up approximately two-thirds of the sample owners, whereas public homeowners make up the remaining one-third. New sales constitute 60% of the housing sample with an average age of 4.55 years as of the transaction date. Based on the price-based sorting process, we put the lower 25th percentile of the housing samples into the low-price segment, and the remainder into the moderate-to-high price market segments. Nearly one quarter of the sample housing transactions occur in the CCR. The average floor of the housing samples fall between the 7th and 12th floors as indicated by the floor dummy of 2. Properties with freehold tenure make up 48.3% of the sample.

Using the ArcGIS tool, we measure the straight line distances (in meters) of each property, which is identified by a unique 6-digit postal code, to the surrounding amenities, such as the nearest Mass Rapid Transport (MRT) stations, shopping centres, bus interchanges, primary schools, expressways and central business district (CBD). These variables are included in the model to control for spatial variations at the building level.

Table 1 Summary of Statistics of Private Properties (Non-landed)

Variable	Obs.	Mean	Standard Deviation
A) Housing Attribute			
Transacted Price	201,774	1,492,146	1,359,952
Investor (=1)	201,774	0.614	0.487
After2010 (=1)	201,774	0.501	0.500
After2013 (=1)	201,774	0.179	0.383
Property Type (condo=1, apartment =0)	201,774	0.661	0.473
Type of Sale (resale=1, new sale=0)	201,774	0.417	0.493
Category (lower 25% =1, other=0) ^a	201,774	0.250	0.433
Shoebox size (yes=1, other=0) ^b	201,774	0.085	0.279
Region (core central=1, other=0)	201,774	0.217	0.412
Floor ^c	201,774	1.751	0.821
Tenure (free hold=1, lease hold=0)	201,774	0.483	0.500
Area (sqm)	201,774	112.498	54.867
Age	201,774	4.546	7.565
B) Distance to Amenities (Metres)			
Distance to Expressway	201,774	861.218	669.661
Distance to CBD	201,774	8,261.547	4,500.582
Distance to MRT station	201,774	709.414	579.047
Distance to hospital	201,774	1,716.452	1,108.646
Distance to bus interchange	201,774	1,869.066	961.534
Distance to shopping centre	201,774	678.884	495.195
Distance to primary School	201,774	657.46	426.849

Notes: price is adjusted to that in 1Q2014 by using CPI.

^a. The lower 25% properties are defined as those in the lower 25% of transaction prices.

^b. Shoebox size properties are less than or equal to 50 square meters.

^c. Floor dummy equals 1 if the condo/apartment is below or equal to 6th floor. Equals 2 if between 7th and 12th levels. Equals 3 if 13th floor or higher.

4.2 Empirical Design

In the policy experiment, we apply the DID strategy to empirically test for variations in housing transaction prices between the policy unconstrained and constrained buyers “before” and “after” the concurrent ownership periods. We use the current registered home address of the buyers to identify their motives in purchasing their current private housing unit. If they are living in a private housing unit, they are likely to buy a new private housing unit for investment. If they are living in a public housing unit, they are likely to be upgraders, who buy a new private housing unit for own-occupation purposes. The semi-log hedonic pricing model is specified as follows:

$$\begin{aligned}
 \ln price_{it} = & \alpha After_t + \beta Investor_i + \gamma After_t \times Investor_i \\
 & + X'_{it} \delta + \lambda_i + \tau_t + \varepsilon_{it}
 \end{aligned}
 \tag{1}$$

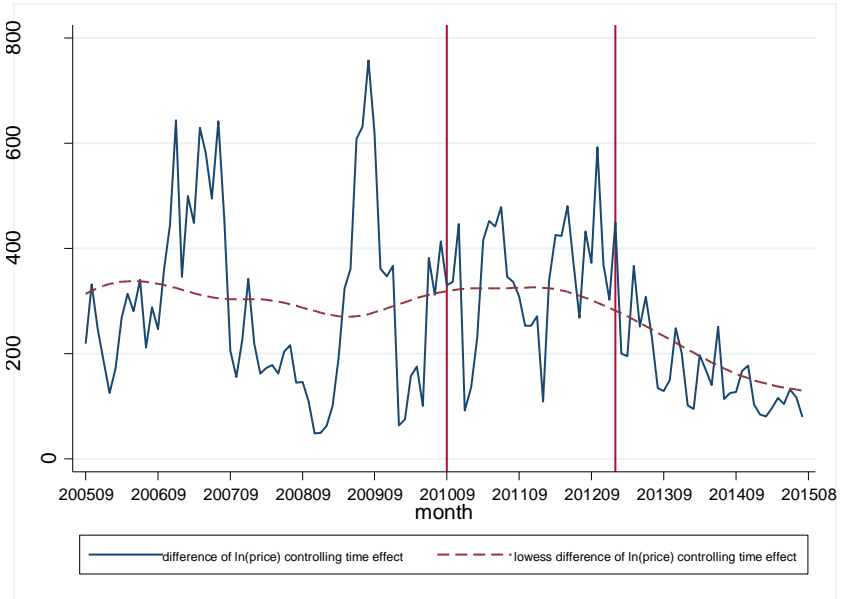
where “ $\ln price_{it}$ ” is the natural logarithm of the transacted price; “ $After2010$ ” is the first time dummy that equals to 1 if a transaction occurs after the introduction of the 2010 policy on 30 August 2010; and “ $After2013$ ” is the second time dummy that equals to 1 if a transaction occurs after the 2013 policy on 12 January 2013; and 0 otherwise. A dummy “ $Investor_i$ ” is the treatment variable that has a value of 1, if he/she is not currently living in a public housing unit, and otherwise 0, if he/she is an owner, whose home address is one that is public housing; X_{it} represents a vector of property attributes, which include property type (apartment or condominium), unit area, lease tenure, floor level, type of sale, property type and age; and a vector of neighbourhood characteristics, which include distance to various amenities (MRT stations, shopping centres, bus interchanges, primary schools, expressways and the CBD). We include the year and quarter fixed effects, τ_t ; and the location fixed effect (captured by the first 2 digits of the postal code), λ_i . ε_{it} is an independent and identically distributed (*i.i.d.*) error term.

Instead of a 3-year treatment window for the concurrent restriction policy in Equation (1), we break down the treatment effects by replacing the “ $After(t)$ ” with a series of year dummies after the 2010 policy, (“ i ” year After 2010”), where ($i=1,2,3,4$, and 5); and the smaller treatment intervals could help to remove potential confounding effects associated with other demand-side housing measures introduced between 2009 and 2013. We also interact each of the “year after the policy (2010)” dummy with the investor dummy in the model, and keep other control variables as in Equation (1).¹²

Figure 2 illustrates the difference in the average housing transaction price (in logarithm terms) between private and public (HDB) housing owners versus time (X-axis), controlling for the year and quarter effects. The bold line represents the difference in transaction price (in logarithm) over time and the dashed line represents the locally weighted scatter plot smoothing (LOWESS) difference in transaction price (in logarithm). The two vertical lines indicate the two rounds of demand restrictions in August 2010 and January 2013, respectively. Before the 2010 policy, the price differences between private housing owners (the treatment group) and public housing owners (the control group) are approximately flat. The former pay relatively higher purchasing prices. The price differences decrease moderately after the 2010 policy, and subsequently the price differences nearly converge after the 2013 policy. The temporal changes in the price differences between the private and the public housing owners provide graphical evidence that supports differential pricing trends in the private housing purchases of private and public housing owners.

¹² We thank an anonymous reviewer for detailed comments and suggestion on the empirical strategies.

Figure 2 Price Difference between Private and Public Owners with Time Effects Controlled



Note: The figure shows the difference in the average monthly housing price (in logarithm) between private and public (HDB) housing owners, with year and quarter effects controlled. The two red vertical lines denote 2010 and 2013 policies sequentially.

Next, we test the effects of the 2010 policy by using transaction data that cover the three-year windows before and after the implementation of the 2010 policy. We then extend the window to 5 years before and after the 2010 policy period and include a second time dummy to capture the effects of the 2013 policy. We run various heterogeneity tests by using sub-samples sorted by sale type (new sale versus resale), region (CCR versus fringe region), market segment (low-end versus moderate-to-high end markets), and unit size (shoebox versus large). We include the interactive transaction volume and price terms to further test the differential behavioral responses of the two types of owners to the demand restriction policies.

5. Empirical Results

5.1 Policy Effects on Private Housing Owners

Table 2 presents the estimation results of Eq. (1). Column (1) shows the results on the treatment effects of the 2010 policy (30th August 2010) with the 3-year pre and post-policy windows. Column (2) replaces the dummy of *After2010*

with a series of year dummies after the policy, as discussed in Section 4.2. Column (3) is the same as Column (1) but uses the 5-year pre- and post-2010 policy windows from September 2005 to August 2015. Column (4) includes the 2013 policy dummy (13rd January 2013). Column (5) is the same as Column (2) but uses the 5-year pre- and post-policy windows. Column (6) presents a placebo test on the parallel pre-trends between the treatment and the control groups in the DID specification. Robust standard errors are reported in parentheses. The sign and significance of the control variables are as expected and statistically significant at the 1% level. Freehold properties are approximately 10% to 14% higher in price than leasehold properties; condominiums are 10 to 11% more expensive than apartments; and resale properties are 5 to 6% less expensive than properties in new and sub-sales.

Based on the 3-year pre- and post- policy window periods, the baseline model in Column (1) validates the rising housing price trends in the housing market. The coefficient on “*After2010*” is statistically significant at the 1% level thus showing a higher post-trend (August 2010 - July 2013) private housing price of 3.36% above the pre-policy price level (July 2007 - July 2010). The increasing price trend after the 2010 policy is persistent when we extend the window period to 5 years before and after the policy (Columns (3) – (4)). However, Column (4) shows that the 2013 policy causes private housing prices to decline by 1.31% relative to the control period (2005-2010), and the result is statistically and economically significant. In Columns (2) and (5) where the year-by-year dummies are used in lieu of the two policy year dummies, we observe significant declining price trends, especially 3 years after the 2010 policy period. A declining price trend is also observed 2 years after the 2010 policy in Column (5), but the effect is less significant than that of the declines in years 3 to 5.

We find that the “*Investor*” dummy has a positive and statistically significant coefficient in all of the specifications in Columns (1) – (5). The higher prices paid by private housing owners may capture larger income effects relative to those of public housing owners. The “*Investor*” variable is a clean identification to separate the buying behaviors between the two groups of owners. If the concurrent ownership policy has a discriminating impact on private housing owners, but not public housing owners, we may expect differentiated responses from the two types of owners. The coefficient, γ , picks up the treatment effect of the concurrent ownership policy, and the negative policy effects are statistically significant, thus indicating that investor purchases dropped by 2.06% relative to those of public owners in the private housing market in the 3-year post-policy window periods (Column 1). When we separate the effects by year (Column 2), the negative policy effects on the purchase prices of investors persist, and the “year-investor” interactive coefficients are statistically significance at a level of less than 1%. The results imply that the policy treatment effects increase incrementally with time (since the introduction of the 2010 policy).

Table 2 Policy Effects on Transaction Price for Non-landed Private Properties (Apartments & Condominiums)

	Log Price					Placebo test 3 years earlier
	3 years pre & post		5 years pre & post			
	(1)	(2)	(3)	(4)	(5)	
After2010	0.0336*		0.0250*	0.0208*		0.0872*
	(0.00332)		(0.00330)	(0.00332)		(0.00623)
After2013				-0.0131*		
				(0.00758)		
Investor	0.0578*	0.0575*	0.0652*	0.0652*	0.0643*	0.0583*
	(0.00175)	(0.00175)	(0.00150)	(0.00150)	(0.00150)	(0.00309)
After2010 × Investor	-0.0206*		-0.0305*	-0.0240*		0.00469
	(0.00208)		(0.00181)	(0.00200)		(0.00474)
After2013 × Investor				-0.0180*		
				(0.00239)		
1 st Year After 2010 Policy		0.0186*			-0.00434	
		(0.00356)			(0.00352)	
2 nd Year After 2010 Policy		0.00412			-0.0474*	
		(0.00494)			(0.00474)	
3 rd Year After 2010 Policy		-0.0181*			-0.105*	
		(0.00638)			(0.00596)	
4 th Year After 2010 Policy					-0.170*	
					(0.00768)	
5 th Year After 2010 Policy					-0.219*	
					(0.00943)	

(Continued...)

(Table 2 Continued)

	3 years pre & post		5 years pre & post			Placebo test 3 years earlier
	(1)	(2)	(3)	(4)	(5)	(6)
1 st Year After × Investor		-0.0115* (0.00284)			-0.0166* (0.00276)	
2 nd Year After × Investor		-0.0240* (0.00262)			-0.0280* (0.00254)	
3 rd Year After × Investor		-0.0235* (0.00268)			-0.0275* (0.00261)	
4 th Year After × Investor					-0.0313* (0.00366)	
5 th Year After × Investor					-0.0717* (0.00404)	
Tenure	0.103* (0.00180)	0.103* (0.00180)	0.140* (0.00152)	0.140* (0.00152)	0.139* (0.00152)	0.148* (0.00336)
Area (sqm)	0.00675* (4.69e-05)	0.00675* (4.69e-05)	0.00650* (4.25e-05)	0.00650* (4.24e-05)	0.00651* (4.25e-05)	0.00605* (8.74e-05)
Age	-0.0093* (0.000155)	-0.00930* (0.000155)	-0.00937* (0.000127)	-0.00936* (0.000127)	-0.00937* (0.000126)	-0.00800* (0.000268)
Property Type	0.101* (0.00189)	0.101* (0.00189)	0.110* (0.00162)	0.110* (0.00162)	0.111* (0.00161)	0.130* (0.00363)
Sale Type	-0.0532* (0.00192)	-0.0535* (0.00192)	-0.0678* (0.00157)	-0.0679* (0.00157)	-0.0682* (0.00157)	-0.143* (0.00348)

(Continued...)

(Table 2 Continued)

	3 years pre & post		5 years pre & post			Placebo test 3 years earlier
	(1)	(2)	(3)	(4)	(5)	(6)
Year Fixed Effect	Y	Y	Y	Y	Y	Y
Quarter Fixed Effect	Y	Y	Y	Y	Y	Y
Planning Sector Fixed Effects	Y	Y	Y	Y	Y	Y
Observations	132,916	132,916	201,774	201,774	201,774	46,187
R-squared	0.866	0.866	0.856	0.856	0.857	0.875

Notes: Robust standard errors in parentheses. * denotes $p < 0.01$.

The dependent variable is the log housing price. The two time dummies, “After2010” and “After2013”, represent the post-policy periods, which has a value of 1, if the time of sale is after August 30, 2010 and January 12, 2013, respectively. “Investor” is the treatment variable that has a value of 1, if he/she is not currently living in a public housing unit, and otherwise 0 for an owner. Tenure is a dummy variable that has a value of 1, if a property has a freehold or 999 year tenure. Area and age are two continuous variables that measure unit size and age of the property. “Type of sale” dummy differentiates a “new” sale unit from a “resale” unit. Other control variables not reported in the table include floor dummies, and distance to CBD, MRT station, hospital, bus interchange, shopping centre, primary school, and expressway.

When a longer 5-year policy window is used, we find a significantly larger price decrease of 3.05% at a level of less than 1% (Column 3). When a policy dummy for 2013 is added, which further restricts the right of SPRs to concurrently own a private housing unit and a public housing flat, we find a further price reduction of 1.8% in the purchases by private housing owners (Column 4). The interaction terms of the investors with the two policy time dummies (*After2010* and *After2013*) are both statistically significant at less than 1%. The results imply that private housing owners pay lower prices relative to public housing owners when they buy comparable private non-landed houses after the 2 rounds of ownership restrictions in 2010 and 2013 were implemented. The demand restrictions imposed on the public housing market seem to generate negative spillover price effects onto the private housing market. The results are also consistent when we break down the policy effects by using the year-by-year policy dummies in Column (5).

We conduct a placebo test to ascertain whether the pre-policy trends in housing prices between the two groups of owners are parallel. It is crucial to validate this assumption for our DID model to ensure that no exogenous shocks occur prior to the policy implementation. In the placebo test in Column (6), we arbitrarily move the policy treatment time three years ahead to 2007 and use the data from 2006 to 2007 to model the pre-treatment price trend, and test this trend against the “placebo” post-treatment trend from 2007 to 2008. The results show that there is no statistically significant treatment effect associated with the “placebo” policy period, and we do not find a significant shift or change in the parallel trends between the housing prices of the investors and public owners observed in the pre-event period after the “placebo” treatment period in 2007.

Our explanation for the negative treatment effects on investors (policy unconstrained buyers) vis-à-vis public housing owners (policy constrained buyers) is as follows: the 2010 and 2013¹³ policies prevent investors from speculating and investing in the resale public housing market and clearly segment the housing markets into owner (public housing market) and upgrader (owner) cum investment (private housing market) markets. In a rising market, investment demand drives up prices and crowds out policy constrained (owners) buyers in private housing markets where the new supply is inelastic. When the market sentiment turns negative, investors, who are more loss-averse (Genesove and Mayer, 2001), are more likely to reduce their investments in the private housing market. However, policy constrained buyers (owners), who have reaped some gain when selling their subsidized (public) house, are less loss-averse and thus less price sensitive in volatile markets relative to investors. The gap left by investors is filled by owner buyers. The impact of the intervention measures that caused relatively larger price declines in transactions by private investors has been, to some extent, absorbed by the demand of

¹³ The 2013 policy further prevents PRs from concurrently owning private and public housing, regardless whether the MOP has been met, and enhances this negative price effect.

owner-buyers, without which private housing prices could have had spiralled more rapidly downward after the shocks.

Our empirical result reveals that the 2013 policy shock has resulted in a smaller price difference between the policy constrained and unconstrained buyers than the 2010 policy shock. Given that 2010 coincided with a rising market, and 2013 coincided with a declining market, we can see relatively stronger responses of buyers to the shocks in a declining market to capture behavior that is consistent with risk-aversion.

It is also plausible to argue that risk aversion behavior can be found in sellers during the two periods, but the level of risk aversion could be asymmetric in the two market conditions. A branch of literature on the counter-cyclical risk aversion behavior argues that risk aversion is stronger during a recession and vice versa (Cohn et al., 2015; Li, 2007). If the 2013 policy shock is smaller, this reflects the risk aversion behaviour of sellers during the down-market cycle. This will only hold if we assume, at the same time, that buyers are either risk-neutral or their risk-behavior is constant during the down-market cycles.

5.2 Heterogeneity Tests

We perform additional heterogeneity tests on the effects of differential concurrent ownership restrictions on prices for comparable houses purchased by investors and owners, which are classified by sale type, location, housing market segment, and unit size.

5.2.1 New Sale versus Resale

For sale type, we sort the housing samples into new sale (including sub-sale, which are units under construction) and resale (completed units) units, based on the state of completion of the project. The resale market consists of completed units, whereas new sales include pre-completion sales either by developers or investors. The results are summarized in Table 3, where Columns (1) and (2) show the estimates for the new sale market, and Columns (3) and (4) show the corresponding results for the resale market. Columns (1) and (3) present the effect of the 2010 policy by using 3-year policy windows, whereas Columns (2) and (4) show the corresponding results with the additional 2013 policy dummy estimated in a 5-year policy window.

The results in Table 3 are consistent with those of the baseline, thus indicating that the concurrent ownership policies produce significantly negative price effects on private housing owners relative to the public housing owners. The treatment effects are stronger in the resale market than the new sale market. For models that use a 3-year window, the effects of the 2010 policy on the new sale and resale markets are estimated to be -2.41% (Column 1) and -3.34% (Column

3), respectively. Both estimates are statistically significant at less than the 1% level. The results are consistent in Columns (2) and (4) with the addition of the 2013 policy dummy, but the effects in the 2013 policy are weaker compared to the 2010 policy.

Table 3 Heterogeneity Tests - New Sale and Sub-Sale versus Resale

	Log Price			
	New Sale & Sub Sale		Resale	
	(1) 3 years pre & post	(2) 5 years pre & post	(3) 3 years pre & post	(4) 5 years pre & post
After2010	0.0466* (0.00461)	0.0315* (0.00468)	0.0257* (0.00443)	0.0212* (0.00441)
After2013		-0.00131 (0.00893)		-0.0384* (0.0118)
Investor	0.0580* (0.00247)	0.0670* (0.00219)	0.0563* (0.00233)	0.0647* (0.00201)
After2010 × Investor	-0.0241* (0.00273)	-0.0297* (0.00259)	-0.0334* (0.00302)	-0.0421* (0.00293)
After2013 × Investor		-0.0167* (0.00288)		-0.0143* (0.00392)
Tenure	0.0719* (0.00288)	0.134* (0.00230)	0.119* (0.00235)	0.140* (0.00204)
Area (sqm)	0.00754* (7.30e-05)	0.00741* (6.85e-05)	0.00561* (5.71e-05)	0.00543* (5.02e-05)
Age	-0.0131* (0.00331)	-0.0291* (0.00289)	-0.00747* (0.000156)	-0.00778* (0.000128)
Property Type	0.0715* (0.00294)	0.0781* (0.00229)	0.134* (0.00249)	0.149* (0.00227)
Year Fixed Effect	Y	Y	Y	Y
Quarter Fixed Effect	Y	Y	Y	Y
Planning Sector Fixed Effects	Y	Y	Y	Y
Observations	80,520	117,616	52,396	84,158
R-squared	0.883	0.875	0.870	0.860

Notes: Robust standard errors in parentheses. * p<0.01.

The dependent variable is the log housing price. The two time dummies, “After2010” and “After2013”, represent the post-policy periods, which has a value of 1, if the time of sale is after August 30, 2010 and January 12, 2013, respectively. “Investor” is the treatment variable that has a value of 1, if he/she is not currently living in a public housing unit, and otherwise 0 for an owner. Tenure is a dummy variable that has a value of 1, if a property has a freehold or 999 year tenure. Area and age are two continuous variables that measure unit size and age of the property. “Type of sale” dummy differentiates a “new” sale unit from a “resale” unit. Other control variables not reported in the table include floor dummies, and distance to CBD, MRT station, hospital, bus interchange, shopping centre, primary school, and expressway.

The new sale models are deemed to be relatively cleaner estimations, which are not likely to be influenced by supply-side shocks, if any. The results on the new sale market further validate the main results in Table 2, thus implying that the concurrent ownership policy adversely impacts the transaction prices of private home owners. Compared to the results in the new sale models, we find larger negative price reactions in private housing purchases in the resale market. The concurrent restriction policy seems to have brought stronger exclusion effects that significantly reduce the demand of private housing owners in the resale market, where owners of resale units could take immediate possession of completed units upon purchase and is traditionally a market segment that receives more speculation.

5.2.2 Core Central versus Fringe Regions

We examine the spatial preference of owners by dividing the private housing market into the CCR and the fringe region. The CCR attracts more private housing owners who pay higher prices for the properties relative to public housing owners and is more preferred for speculation. The fringe region especially attracts public housing owners who buy houses for their own occupation (consumption). The first two columns of Table 4 show the results for the fringe region, and the last two columns show the results for the CCR. The treatment effects are not statistically significant for the fringe region. However, the price reduction is statistically significant at -4.76% for the CCR after the 2010 policy (Column 3), and a larger price reduction of -6.41% is observed after the 2013 policy in 2013 (Column 4).

5.2.3 Mass-Market Housing Segment

We further test the treatment effects in the mass-market segment vis-à-vis the moderate- and higher-end segments in the private housing market. The mass-market private housing segment covers the lowest 25th percentile of the private housing market by housing price. Table 5 compares the results for the mass markets (the lowest 25th percentile) and the moderate- and high-end segments of the private housing market. The treatment effect is not statistically significant in the mass market in Column (1), where a 3-year window and one policy dummy are used in the estimation. However, we find weakly significant policy effects in the mass-market segment of the private housing at the 10% level in Column (2), where a 5-year window and the two policy dummies are used in the estimation. For the other (moderate to high-end) market segments, the 2010 policy shocks reduce private housing prices by 2.3% for private house owners relative to public housing owners, and the coefficient is statistically significant at the 1% level (Column 3). The results remain robust when the 2013 policy is added (Column 4), although a smaller incremental impact of 1.72% is observed with the 2013 intervention.

Table 4 Heterogeneity Tests – Core Central Region versus Fringe Region

	Log Price			
	Fringe Region		Core Central Region	
	(1)	(2)	(3)	(4)
	3 years pre & post	5 years pre & post	3 years pre & post	5 years pre & post
After2010	0.0263* (0.00324)	0.0115* (0.00323)	0.0291* (0.0103)	-0.00125 (0.0103)
After2013		-0.0191** (0.00772)		-0.0246 (0.0187)
Investor	0.0377* (0.00174)	0.0381* (0.00143)	0.124* (0.00565)	0.132* (0.00477)
After2010 × Investor	-0.00296 (0.00209)	0.000520 (0.00199)	-0.0476* (0.00702)	-0.0393* (0.00717)
After2013 × Investor		-0.00119 (0.00236)		-0.0641* (0.00882)
Tenure	0.0912* (0.00182)	0.126* (0.00153)	0.135* (0.00528)	0.147* (0.00421)
Area (sqm)	0.00689* (4.95e-05)	0.00665* (4.07e-05)	0.00624* (8.65e-05)	0.00604* (7.55e-05)
Age	-0.00959* (0.000171)	-0.00909* (0.000136)	-0.00929* (0.000326)	-0.0106* (0.000262)
Property Type	0.0805* (0.00189)	0.0877* (0.00152)	0.154* (0.00475)	0.146* (0.00378)
Type of Sale	-0.0493* (0.00208)	-0.0620* (0.00163)	-0.0457* (0.00436)	-0.0574* (0.00351)
Year Fixed Effect	Y	Y	Y	Y
Quarter Fixed Effect	Y	Y	Y	Y
Planning Sector Fixed Effect	Y	Y	Y	Y
Observations	108,433	158,039	24,483	43,735
R-squared	0.822	0.811	0.840	0.824

Notes: Robust standard errors in parentheses. * p<0.01.

The dependent variable is the log housing price. The two time dummies, “After2010” and “After2013”, represent the post-policy periods, which has a value of 1, if the time of sale is after August 30, 2010 and January 12, 2013, respectively. “Investor” is the treatment variable that has a value of 1, if he/she is not currently living in a public housing unit, and otherwise 0 for an owner. Tenure is a dummy variable that has a value of 1, if a property has a freehold or 999 year tenure. Area and age are two continuous variables that measure unit size and age of the property. “Type of sale” dummy differentiates a “new” sale unit from a “resale” unit. Other control variables not reported in the table include floor dummies, and distance to CBD, MRT station, hospital, bus interchange, shopping centre, primary school, and expressway.

Table 5 Heterogeneity Tests – Lower 25% versus Other Market Segments

	Log Price			
	Lower 25% Market Segment		Other Market Segment	
	(1)	(2)	(3)	(4)
	3 years pre & post	5 years pre & post	3 years pre & post	5 years pre & post
After2010	0.0277* (0.00359)	0.00609 (0.00406)	0.0293* (0.00375)	0.0194* (0.00367)
After2013		-0.0247** (0.00972)		0.00266 (0.00754)
Investor	0.00788* (0.00187)	0.0136* (0.00155)	0.0577* (0.00204)	0.0608* (0.00183)
After2010 × Investor	-0.000291 (0.00250)	-0.00491* (0.00258)	-0.0230* (0.00238)	-0.0214* (0.00232)
After2013 × Investor		0.00483 (0.00405)		-0.0172* (0.00239)
Tenure	0.0443* (0.00222)	0.0898* (0.00189)	0.112* (0.00184)	0.130* (0.00165)
Area (sqm)	0.00544* (0.000206)	0.00541* (0.000112)	0.00596* (4.60e-05)	0.00575* (4.23e-05)
Age	-0.00690* (0.000406)	-0.00832* (0.000258)	-0.00846* (0.000151)	-0.00837* (0.000127)
Property Type	0.0340* (0.00225)	0.0639* (0.00181)	0.0890* (0.00198)	0.0917* (0.00170)
Type of Sale	-0.0157* (0.00324)	-0.0385* (0.00227)	-0.0801* (0.00196)	-0.0823* (0.00166)
Year Fixed Effect	Y	Y	Y	Y
Quarter Fixed Effect	Y	Y	Y	Y
Planning Sector Fixed Effects	Y	Y	Y	Y
Observations	33,294	50,444	99,622	151,330
R-squared	0.541	0.524	0.847	0.836

Notes: Robust standard errors in parentheses. * p<0.01.

The dependent variable is the log housing prices. We run the models by using two sub-sample of housing transactions sorted by price range into the segment with the lowest 25% percentile, and the other “moderate and high” price segments. The two time dummies, “After2010” and “After2013”, represent the post-policy periods, which has a value of 1, if the time of sale is after August 30, 2010 and January 12, 2013, respectively. “Investor” is the treatment variable that has a value of 1, if he/she is not currently living in a public housing unit, and otherwise 0 for an owner. Tenure is a dummy variable that has a value of 1, if a property has a freehold or 999 year tenure. Area and age are two continuous variables that measure unit size and age of the property. “Type of sale” dummy differentiates a “new” sale unit from a “resale” unit. Other control variables not reported in the table include floor dummies, distance to CBD, MRT station, hospital, bus interchange, shopping centre, primary school, and expressway.

The negative price effects in the moderate to the high-end segments of the housing market reflect the anti-speculation effect of the policy, as the higher-end market segment is traditionally more preferred by investors.

5.2.4 “Shoe-Box” Apartments

Some public housing owners buy a second private housing unit for investment purposes, while keeping the current public housing unit for their own occupation. They sit on unrealized gains, if they choose not to sell their existing public housing unit. Without the realized gains, they may buy smaller housing units for investment purposes. Some private housing owners, who can never invest in resale public housing after the concurrent policy, are likely to invest in smaller private housing units too, as alternatives to resale public housing. Buying smaller housing units, which are also referred in the local market as “shoe-box” units with a unit area of 50 sqm or smaller, requires less upfront capital because the absolute value of the purchase price is lower than that of larger sized units.

To test for further robustness, we repeat the DID models in Equation (1) based on the shoe-box private housing units (unit size of less than 50 m²) and other private housing units. The results are summarized in Table 6. When a 3-year sample window is used in Columns (1) and (3), the coefficient on the “Investor” dummy indicates that private housing owners pay 2.0% and 5.89% more on average than public housing owners for comparable shoebox and larger private units, respectively. The average prices are 2.46% and 6.63% higher when a longer 5-year window is considered in Columns (2) and (4), respectively. We also find significant treatment effects in both segments of the private housing markets in the post-policy period in 2010 for all the models, where the interactive “Investor” and “After2010” terms show relatively stronger policy effects of -2.84% to -3.43% for the large-size private housing market compared to -1.11% to -1.51% for the “shoe-box” apartments.

When the 2013 policy dummy in 2013 and the sample window is extended to 5 years as shown in Columns (2) and (4), we find no significant negative price effects in the “shoe-box” segment, but significant price effects estimated at -2.18% in the larger-size private housing segment. The significant decrease in housing price among large properties, which are traditionally preferred by investors, again shows support for the anti-speculation impact of the policy. The smaller or lack of impact on shoebox size properties is possibly from the alternative investment purpose of public and/or private housing owners, which cancels out the otherwise even more reduced housing price.

Table 6 Heterogeneity Tests – Shoebox Size versus Large Size Properties

	Log Price			
	Shoebox Size Properties		Large Size Properties	
	(1)	(2)	(3)	(4)
	3 years pre & post	5 years pre & post	3 years pre & post	5 years pre & post
After2010	0.0332* (0.00488)	0.0330* (0.00478)	0.0449* (0.00331)	0.0313* (0.00329)
After2013		0.00417 (0.0125)		0.00361 (0.00761)
Investor	0.0205* (0.00409)	0.0246* (0.00391)	0.0589* (0.00174)	0.0663* (0.00149)
After2010 × Investor	-0.0111** (0.00439)	-0.0151* (0.00433)	-0.0284* (0.00207)	-0.0343* (0.00200)
After2013 × Investor		0.00232 (0.00338)		-0.0218* (0.00236)
Tenure	0.0892* (0.00466)	0.141* (0.00421)	0.123* (0.00182)	0.152* (0.00153)
Area (sqm)	0.0190* (0.000197)	0.0197* (0.000188)	0.00615* (4.52e-05)	0.00600* (4.11e-05)
Age	-0.00635* (0.00167)	-0.00781* (0.00138)	-0.00892* (0.000147)	-0.00925* (0.000121)
Property Type	-0.00256 (0.00395)	0.0143* (0.00344)	0.0830* (0.00179)	0.0915* (0.00153)
Type of Sale	-0.0253* (0.00705)	-0.0235* (0.00590)	-0.0869* (0.00185)	-0.0957* (0.00152)
Year Fixed Effect	Y	Y	Y	Y
Quarter Fixed Effect	Y	Y	Y	Y
Planning Sector Fixed Effects	Y	Y	Y	Y
Observations	13,681	17,157	119,235	184,617
R-squared	0.876	0.862	0.869	0.860

Notes: Robust standard errors in parentheses. * p<0.01.

The dependent variable is the log housing prices. We run the models using two sub-samples of housing data sorted by the unit size into the “shoe-box” segment (with unit floor area of below 50 sqm) and the segment with larger (above 50 sqm) unit size. The two time dummies, “After2010” and “After2013”, represent the post-policy periods, which has a value of 1, if the time of sale is after August 30, 2010 and January 12, 2013, respectively. “Investor” is the treatment variable that has a value of 1, if he/she is not currently living in a public housing unit, and otherwise 0 for an owner. Tenure is a dummy variable that has a value of 1, if a property has a freehold or 999 year tenure. Area and age are two continuous variables that measure unit size and age of the property. “Type of sale” dummy differentiate a “new” sale unit from a “resale” unit. Other control variables not reported in the table include floor dummies, distance to CBD, MRT station, hospital, bus interchange, shopping centre, primary school, and expressway.

5.3 Discussion and Additional Evidence

Governments, especially those of many Asian countries, have taken stern measures to prevent unhealthy flipping activities in housing markets that cause excessive price increases. For the measures to be effective in preventing flipping, they must be forceful and impactful enough to change the behaviour of flippers. In our natural experiments on the private housing market of Singapore, the concurrent ownership restrictions show negative effects on investment demand after the first round of policy implementation in 2010. The policy effect is reinforced after the second round of restrictions in 2013 that are extended to cover SPRs. The coefficient on the policy dummy “After2013” in Column (4) of Table 2 shows that the negative price effects on private housing owners are significantly stronger after the 2013 policy.

Unlike other cooling measures (such as the LTV and SSD), which are applied indiscriminately to all housing owners, the results show that the concurrent ownership policies have only significant (differential) demand-dampening effects on investors (policy unconstrained buyers), but not on policy constrained owner buyers. The differential responses to the shocks associated with the concurrent ownership policies suggest that investors and owners have different loss aversion behavior in down markets. Investors, who are more loss-averse (Genesove and Mayer, 2001), set lower expected prices, and are less willing to buy houses for investment purposes in down markets. However, policy constrained buyers (owners), who have reaped some gain when selling their subsidized (public) houses, are less loss-averse and thus more likely to buy houses at prices that are higher than investors in the private market in volatile markets.

When investors buy fewer houses in the private housing market, the gap is filled by owner buyers. Therefore, the impact of the intervention measures that caused relatively larger price declines in transactions by private investors has been, to some extent, absorbed by the demand of owner-buyers without which private housing prices could have had spiralled more rapidly downward after the shocks. We find further evidence based on the changes in transaction volume in the private housing market by the two group of owners. We aggregate the transaction volumes for three different 1-year windows that cover one pre-treatment (September 2009 – August 2010) and two post-treatment (September 2010 – August 2011 and September 2011 – August 2012) periods, and sort the transaction volume by sale type, location, and price segment and unit size investors (Panel A) and housing owners (Panel B) groups and report the statistics in Table 7. We do not find a significant reduction in the aggregate transaction volume by the two groups of owners in the private housing markets in the post-policy periods from September 2010 to August 2012. We observe increases in the transaction volume of investors from the pre-policy demand of

12,442 units to 14,843 units (19.30%) and 15,651 units (5.44%) in the two window periods of 2010-2011 and 2011-2012, respectively. However, the transaction volume of the owners significantly increases from 7,259 to 9,564 units (31.75%) and 13,712 units (43.37%) during the same window periods, respectively.

We also find significant variations in demand between investors and owners in the two-year post-demand restriction periods. The traditional segments of the housing market dominated by investors, such as the CCR, resale market, moderate-to-high-end segments (upper 75% percentile) and large units see a significant reduction in transaction activities by investors. We also find significant increases in the demand by owners, especially in the moderate-to-high end segments of the markets. The results seem to suggest that public housing upgraders move up the “quality” curve in the upward mobility process, especially after the demand restriction shocks.

Next, we collect additional data on the status of housing owners for a sub-sample of transactions and use the information to further separate “owner occupiers” and “investors”. Based on the differences in the registered home address of the owners and the address of the new private housing unit purchased, we can determine whether an investor buys a second private housing unit for investment purposes, and denote the investor with a dummy [“Second” =1]; otherwise, he/she is identified as an owner occupier (policy constrained buyer), as denoted by [“investor” = 0]. Due to limitations as the data are only available up to 2012, we conduct the robustness tests by only using the first round of policy shocks in 2010 for three sub-samples, which include private new sales, sales in the CCR, and the mass-market housing units (lowest 25th percentile). The results in Table 8 show that private housing buyers, who buy a second house for investment purposes, feel significantly stronger price shocks compared to owner-occupiers in post-policy sales for all three sub-markets.

To conclude, our test results reveal significant heterogeneity in the responses, and we show that the impact is stronger in the high-end market segment, which is represented by houses sold in the CCR in the high price segment with a large floor area. Given that the high-end market appeals more to investors including foreigners, the policy shocks are felt more in this high-end segment of the market relative to the mass-market. One key takeaway from the policy shock is that demand restrictions create differentiated impact, and investors, especially those in the high-end market, tend to be more sensitive to demand shocks in the market.

Table 7 Summary of Annual Transaction Volume

	Sep 2009 – Aug 2010 (1)	Sep 2010 – Aug 2011 (2)	Sep 2011 – Aug 2012 (3)
Panel A. Investors (Policy unconstrained buyers)			
All properties	12442	14843	15651
Resale	6180	7090	6220
New sale	6262	7753	9431
Core central region	4205	3683	2632
Fringe region	8237	11160	13019
Lower 25%	2096	1891	2568
Upper 75%	10346	12952	13083
Shoebox size	914	1470	1764
Non-shoebox size	11528	13373	13887
Panel B. Owners (Policy constrained buyers)			
All properties	7259	9564	13712
Resale	3569	3402	3150
New sale	3690	6162	10562
Core central region	1031	811	614
Fringe region	6228	8753	13098
Lower 25%	2607	2695	4172
Upper 75%	4652	6869	9540
Shoebox size	969	1677	2502
Non-shoebox size	6290	7887	11210

Note: This table summarizes the annual transaction volume before and after the 2010 policy in August 2010. The transaction volume indicates the demand over the three sub-periods, which include one pre-policy period (September 2009 to August 2010) and two post-policy periods (September 2010 to August 2011 and September 2011 to August 2012).

6. Conclusion

This paper uses the DID method to test the asymmetric effects of the concurrent ownership policies in Singapore on private housing investors and public housing upgraders (owners). Unlike other cooling measures introduced between 2009 and 2015 that are applied with less discrimination across the private housing market, the concurrent ownership policies generate “exclusionary” effects that prohibit private investors from buying in the (resale) public housing market. The policies do not, however, prevent public housing owners from upgrading to the private housing market.

Based on the home address of the buyers as a means of identification, we sort the sample buyers into an investor group (treatment) and an owner-buyer group (control), and test if the demand restrictions create asymmetric responses from the two groups of buyers in periods of negative policy shocks. If the demand shocks are non-discriminatory, we should not find significant changes in the housing prices in the transactions between the two groups of buyers before and

Table 8 Robustness Check: Policy Time, Owner Type, and Investment Motive

	Log Price		
	(1) New/sub sale	(2) Core central region	(3) Lowest 25%
After2010	0.0586** (0.0261)	0.117** (0.0559)	0.0457 (0.0279)
Investor	0.00256 (0.0232)	0.0808 (0.118)	0.137* (0.0270)
Investor	0.0104 (0.0232)	0.0203 (0.118)	0.0992* (0.0273)
After2010 × Investor	-0.0246** (0.0115)	-0.0594** (0.0266)	-0.00880 (0.0167)
Investor × Second	0.0390*** (0.0237)	0.0239 (0.119)	-0.119* (0.0278)
After2010 × Second	-0.0602** (0.0247)	-0.167* (0.0595)	-0.0572** (0.0270)
Property attribute	Y	Y	Y
Year Fixed Effect	Y	Y	Y
Quarter Fixed Effect	Y	Y	Y
Planning Sector Fixed Effects	Y	Y	Y
Observations	11,174	3,419	5,024
R-squared	0.869	0.813	0.494

Notes: Robust standard errors in parentheses. * $p < 0.01$, ** $p < 0.05$, *** < 0.1 .

The time period covers September 2005 to November 2012. The dependent variable is the log housing price. We only use three sub-samples of data on new/sub-sale, CCR and the lowest 25% percentile. A new “investor” dummy, which has a value of 1, if a owner is an investor, which is identified by the existing home address and the new private house address; otherwise, the owner is an “owner occupier” and has a value of 0. The time dummy, “After2010”, represents the post-policy periods, which has a value of 1, if the time of sale is after August 30, 2010. “Second” is the variable that has a value of 1, if the buyers is a private housing buyer who buys a second private housing unit for investment purpose, otherwise 0 for an owner. Other control variables not reported in the table include tenure, area, type of sale, floor dummies, and distance to CBD, MRT station, hospital, bus interchange, shopping centre, primary school, and expressway.

after the policy periods.¹⁴ Our results, however, show that the transaction prices of investors are 2.4% and 1.8% lower than comparable transactions of public housing upgraders, in the post-policy periods of 2010 and 2013, respectively. The declines in the transaction volume of investors in the post-policy periods is additional evidence that supports the differential effects of the demand restriction policies. The results remain significant when the first and the second

¹⁴ The results are different from the views of real estate consultants and analysts, who predicted that this policy was likely to dampen the ability of HDB upgraders to own private property (Shankari, 2010).

rounds of policy shocks are jointly tested, and when 3-year and 5-year windows are used in the estimation. The results cannot reject the hypothesis that both investors and owners have different risk-aversion behaviors when buying private houses in down markets.

We observe stronger policy effects in the resale market relative to the new sale market. We also find stronger evidence of the treatment effects in the popular segments of the investor markets, which include the CCR (relative to the fringe region), moderate to-high price market (relative to the mass market segment), and larger-size market (relative to the “shoe-box” segment). Using a sub-sample of transactions where we directly identify investors and owner-occupiers, we validate the findings that investors face a higher negative impact when they buy a “second” private house for investment purposes relative to owner-buyers. However, we cannot rule out the investment motives of public upgraders, who continue to stay in their public housing unit while buying a second private housing unit for investment purposes. The policy unconstrained private buyers who buy a private house for their own occupation could also possibly bring down the estimation of our results, where the estimate represents only a lower bound of the effect of the concurrent policies.

One caveat of the current study is that our evidence of asymmetric price responses between investors and homeowners are correlated with declines in investment sales; however, we do not find significant positive price effects of owner buyers in response to the policy shocks, which is more consistent with demand substitution effects. Further empirical works could be done in the future, subject to the availability of data.

One useful policy implication is that unlike other macro-prudential measures and transaction tax policies that are applied with less discrimination, the demand restrictions create different discriminatory treatment effects on investors and owner-occupiers. Therefore, policy makers could use the demand restrictions to target only a selected group of buyers whose buying activities directly or indirectly cause excessive price increases in the housing markets.

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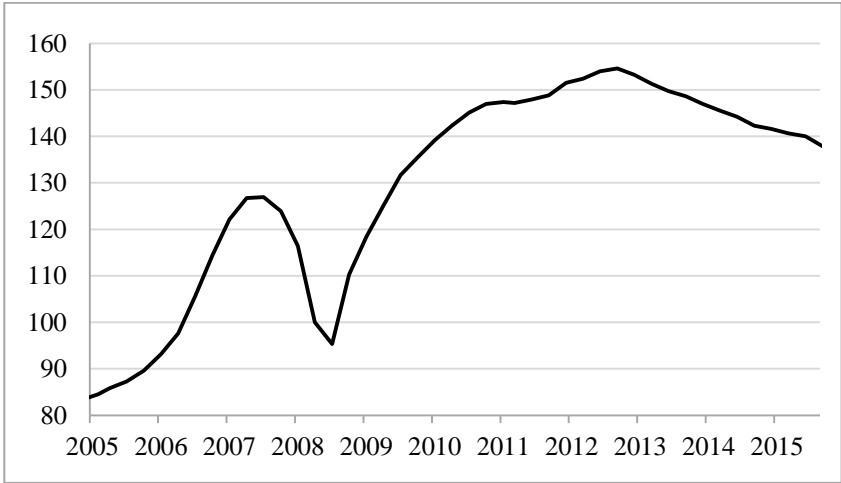
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Appendices

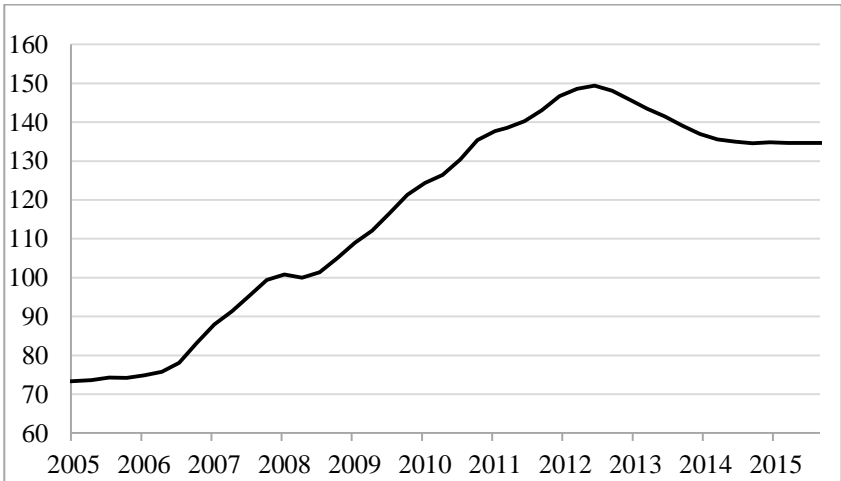
Appendix A Figures

Figure A1 Private Residential Property Price Index of Singapore (2005-2015)



Note: Source from URA, Singapore

Figure A2 Public Housing Resale Price Index of Singapore (2005-2015)



Note: Source from HDB, Singapore

Appendix B Description of Key Variables

Variable	Variable Description	Unit of Measurement
Log Price	Natural logarithm of transacted price (Dependent Variable)	Singapore dollars SGD (\$)
Area	Floor area of the transacted unit	Square metre (Sqm)
Age	Age of the transacted property at the point of transaction	Years. The age of uncompleted projects is 0.
Tenure	Classifications of the tenure include freehold, 99 year leasehold, and 999 year leasehold and higher	“1”, if the tenure is less than 104 years; “2”, if the tenure is between 104 and to 999 years; and “3”, if it is a freehold tenure.
Type of Sale	Determination of whether the transacted property is sold before or after the property is completed (temporary occupation permit)	“0” for ‘New Sale’ or ‘Sub Sale’; and “1” for ‘Resale’
Property Type	Determination of whether the property is apartment or condominium.	Coded “0”, if a house is ‘Apartment’ and “1” if a house is ‘Condominium’.
HDBOwner	Determine if the current registered address of the purchaser is currently residing in private or HDB address.	“0”, if a purchaser lives in a private housing unit and “1” if purchaser lives in an “HDB” (public housing). If owner’s identity is missing, “NA” is assigned.

(Continued...)

(Appendix B Continued)

Variable	Variable Description	Unit of Measurement
After2010 and After2013	Determine if the transaction occurred before or after policies are implemented (30 th August 2010 or 12 th January 2013)	“0”, if a transaction occurred before the policy date (30 th August 2010 or 12 th January 2013), and “1” if the transaction occurred after the two policy dates.
Category	Determine the housing segment is either in the mass-market or the luxury housing segment.	“1” for the mass market segment, which include the lowest 25% percentile of the sample, and “0” for moderate to high end segments.
Region	Determine housing located in the central region and the other regions.	“0”, if a house is located in other region; and “1” if a house is located in the CCR.
Distance to CBD	Distance from the transacted property to CBD	Metres
Distance to Shopping Centre	Distance from the transacted property to shopping centres	Metres
Distance to Hospital	Distance from the transacted property to hospital	Metres
Distance to Expressway	Distance from the transacted property to expressway	Metres
Distance to Primary School	Distance from the transacted property to primary school	Metres
Distance to MRT Stations	Distance from the transacted property to MRT stations	Metres
Distance to Bus Interchange	Distance from the transacted property to bus interchange	Metres

